Vol. XVIII. No. 3 Whole No. 149

MARCH, 1918

SCHOOL SCIENCE AND MATHEMATICS

A Journal for All Science and Mathematics Teachers

Founded by C. E. Linebarger

SMITH & TURTON, Publishers
Publication Office, Mount Morris, Illinois
CHICAGO OFFICE, 2059 East 72nd Place, CHICAGO, ILL.

Published Monthly October to June, Inclusive, at Mount Morris, Illinois
Price, $2.50 Per Year; 30 Cents Per Copy

Entered as second-class matter March 1, 1913, at the Post Office at Mount Morris, Illinois, under the Act of March 3, 1879.

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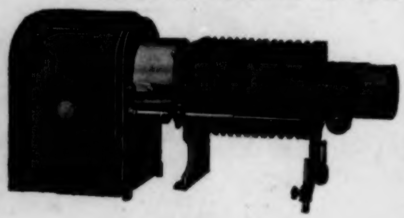

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VOL. XVIII, No. 3 MARCH, 1918 WHOLE No. 149

TEACHING HIGH SCHOOL PUPILS THE INSECTS.[1]

By JEROME ISENBARGER,

Senn High School, Chicago, Ill.

The statement needs no amplification that to arrive at any results which are worth while in the teaching of the subject of insects in the high school, the teacher must have well-defined aims which he expects to follow out. It is true also that in the last two decades high school zoology teaching has undergone a distinct metamorphosis if we are to judge by comparing the latest texts with the older ones. Considering the question as to whether the difference in the texts is accounted for by a change in aims or a change in method, I am inclined to think that the subject matter of our modern courses has been selected with a view to accomplishing purposes which were not thought of in connection with some of the earlier courses.

In addition to the magic transformations, exceptional beauty, examples of superior instinct and intelligence, and other interests, we have the relation of insects to man and other animals which gives the subject a solid, practical basis which is universal in its appeal.

According to Sanderson (1912), a conservative estimate of the tax imposed upon the people of the country by insects puts it at more than a billion dollars, and this does not include the havoc wrought by the typhoid fly, which probably amounts in loss to the people in money alone to another billion of dollars. Who pays the tax? The farmer who is more directly concerned receives a shorter crop, but he gets higher prices for the produce he has to sell, due to the depredations of insects. So, after all, the common people pay the price of ignorance. So the solution of the insect problem concerns each person whether living in the city or on the farm. Information on the subject needs to be generally disseminated in order that we may not have the igno-

[1]Read at the High School Conference, University of Illinois, Urbana, Nov. 23, 1917.

rant person who will breed insect pests to the detriment of a whole community or who will interfere with the problem by killing, either directly or indirectly, the song birds and other insectivorous animals, by harboring uncontrolled cats which destroy on the average, according to Forbush, fifty song birds a year.

The principal purposes to be achieved in the study of insects should be, (1) to awaken in the pupil an abiding interest in insect life, (2) to help the pupil to realize that the problem of insect control is one of interest to all persons whether living in the city or on the farm and that all persons should have some knowledge of insect structure, instinct, and metamorphosis in order that the problem can be intelligently dealt with, (3) to teach the pupils biological principles with the insects as examples, (4) to give training in original thought and accurate observation from a study of the living insect.

The selection of types for the work should depend upon the locality and the practical interests of the pupils. The insects chosen for use in a farming district should be, as far as possible, those which affect the farm crops of the region or in some other way touch the life of the boys and girls. The selection of forms for study in the city should be such as to convince the pupil that he is face to face with the insect problem and should have a part in its solution.

In any case the choice should be made so that at least one stage in the life of the insect can be studied from the living form and it will be better still if the whole life history can be studied in the laboratory or in the field from the living specimens. It is much more important that we are able to study the living animal than any attempt at following the phylogenetic sequence which substitutes preserved material for the living specimens.

The first form studied in the Senn High School at the beginning of the fall semester is the caterpillar of the Cecropia or of the Polyphemus moth. As a matter of fact we always have both. The reasons for introducing the work with these forms are as follows: (1) They are large in size and the external features are simple. (2) They are easily found along with their pupae during the early part of September. (3) They are occasionally found as pests on shade trees and shrubbery, and hence are of some economic importance to city people.

For individual study, each pupil is supplied with a glass jar containing living caterpillars, pupae, and leaves of the food plant. For class study, the caterpillars are kept in cages and fed moistened leaves until they spin their cocoons.

Dried specimens in Riker mounts serve for the study at this time of the external features of the Cecropia or Polyphemus moth. The cocoons which were spun in the laboratory are put away in the laboratory or in a closed box out of doors where they are left until time for the appearance of the adult moth when they are placed in the cages so that the processes may be watched by the pupils. It should be stated that the cocoons in the laboratory should be sprinkled occasionally with water during the winter.

Other life histories of Lepidoptera which may be worked out in the laboratory are those of the cabbage butterfly, black swallow-tail butterfly, mourning cloak butterfly, monarch butterfly, and viceroy butterfly. If properly directed, pupils will bring much of this material into the laboratory where all of the pupils can watch the transformations.

While I do not place emphasis upon the systematic phase of the study, yet I do find it a good plan to organize the work on insects around eight or nine distinct orders and have the pupils learn thoroughly the distinguishing characteristics of each order. The insects can be classed later on any other basis which seems desirable, "Insects injurious to man and animals," "Insects injurious to garden crops," "Beneficial insects" being suggestive topics for such classification.

In order that the class may have early the data necessary for making a sanitary survey of the school district, the Diptera are taken for the second study. It is the intention in this work to show the house fly at its worst so I make no apology for bringing into the laboratory such repulsive material as a seething mass of wriggling maggots. I had little difficulty this year at the time the fly was the topic in stocking my laboratory garbage can with an abundant supply of fine material by making a few select scoops of garbage from a pail which I found without a cover near the school.

The material with which each pupil is supplied at the beginning of the study of the house fly is a cotton-stoppered glass tube containing several full-grown maggots. But introducing the garbage can this year gave the pupils an opportunity to see without a great stretch of the imagination the effect of carelessness in the disposal of garbage. One peep into our garbage can was sufficient to drive the lesson home. At the close of the day's work the tubes containing the maggots are left lying on the side so that the maggots can reach the cotton into which

they will work their way to pupate. In all probability some pupae are found when the class returns the following day. The pupae develop in the cotton and in due time come out of the cotton as full-grown flies. The pupils will surely see some of them emerging from the puparium. In case a pupa has formed between the plug of cotton and the side of the glass tube, the method an emerging fly uses in working its way through solid media by means of the bladder-like structure which extends from the front of the head is observed by the pupils with great interest.

Because of its relation to human welfare the mosquito must be included in any well-ordered course in the study of the insects. Eggs, wrigglers, and pupae are usually found together in quiet streams and in ponds during the summer months. We have gotten them from standing water in a greenhouse in midwinter. These are studied in small aquaria. But I have also found this material good for demonstration, using a live cell on the stereopticon. It is not unusual to see the imago emerging while the image is being thrown upon the screen. A few small minnows placed in the aquaria and a film of oil placed on the surface of the water in the live cell demonstrate in a striking manner the methods which may be used in dealing with these pests.

The sanitary map which deals particularly with the relation of the existence of conditions favorable to the breeding of flies and mosquitoes to the prevalence of disease in the community should be started as outside work as soon as the work in class with the flies is finished. We have a set of stereopticon views on the house fly as a carrier of disease which is used to introduce the work of the sanitary survey.

I have found by experience that when this work is begun it should be pushed through rapidly. The pupils will get more data in a week if crowded than they will get in a month if the work is allowed to drag.

The school district is divided into approximately equal small districts, each containing eight or ten blocks, and a small district is assigned to one student or in the case of the girls to two working together. A mimeographed sheet directs each pupil to make a map of his assigned district. On this map are located cases of transmissible disease. Sanitary conditions which are to be located are cesspools, sewage dumps, sewer outlets, marshes, stagnant pools, open garbage pails, and manure heaps. Other data shown on the map are public restaurants and stores where

flies are allowed access to food, and places where there is much spitting on floors or walks. Each pupil is asked to write a summary of the conditions as he found them and try to show some connection between the health of the community and the sanitary conditions, especially with reference to the possibility of transmission of disease by flies and mosquitoes. Along with this summary is given an estimate of what remains to be done to make the community an ideal place in which to live. The boys and girls as citizens of the community are thus brought face to face with the fact that the problems of a city are of vital interest to everyone alike and everyone should have a part in their solution. Our people need to grow up in an atmosphere which will tend to develop a civic consciousness based upon the idea of individual responsibility.

If one will take the mortuary statistics of a city or county by months for a year and arrange the data to form a graph of deaths from diarrheal diseases in children, a curve is formed which rapidly rises with the appearance of flies and gradually falls as the flies disappear. There are approximately three times as many deaths from these diseases in August as there are in January. There may be other reasons, but the filth fly is certainly a prominent contributing cause.

While we are insisting upon clean premises it cannot be emphasized too strongly that eternal vigilance will go a step farther than to destroy the breeding places for flies; it will lead to the destruction of the breeders. I am inclined to think that it is good zoology to include instruction in the construction of the best fly trap and direction as to how such a trap should be used. In this connection I desire to call attention to an article on the subject by Dr. Hodge in the February, 1916, issue of the *Nature Study Review*. Quoting from this article, "Let it generally be known that wherever filth flies are, there is filth and the likelihood of disease, and that no clean people will buy food in filthy, fly-besmeared stores or feel at home in fly-filled houses, and we will soon begin to live in a decently clean country."

The best specimen of living beetle available at the time that insect is wanted for our work is the locust beetle. It is found upon the blossoms of the goldenrod. With its black and yellow stripes it fits into the pattern of the shadow and yellow of the blossoms, exhibiting protective resemblance to a remarkable degree. The beetle has been referred to as an example of the so-called protective mimicry. It is supposed to mimic a wasp.

Each pupil is given a tube stopped with cotton and containing a sprig of goldenrod and one or more of the beetles for the laboratory study. I have not found it possible to find the borer and pupa of this beetle, so have had to depend upon preserved specimens of the June beetle for the study of the grub and pupa of the beetle. It is possible that both of these might be found alive in compost heaps at the time when needed. Meat and fish scraps placed in a quart fruit jar, the jar uncovered and placed on the side among the weeds of a vacant lot, will attract scavenger beetles and give an opportunity for studying a most interesting life history. Ladybird beetles, adult and larvae, placed in cotton-stoppered tubes with plant lice, offer interesting studies in the habits and transformation of an insect which is of considerable economic importance.

The Hemiptera may be illustrated in the laboratory by several of the larger bugs, giant water bugs, cicada and others, but I have found it best to study bugs in the field.

The squash bug can usually be found in the gardens in various stages of development during the early fall. For the city student, information concerning the identification, habits, and control of plant lice and scale bugs is decidedly practical and should be treated thoroughly. The same may also be said of this work for the pupil living in the country town or on the farm. I am convinced that a good spray outfit should be a part of the equipment of every high school laboratory.

Within three blocks of the school building we find scurfy scale, oyster-shell scale, cottony maple scale, woolly apple aphis, and several other aphids of lesser importance. It is quite necessary that the pupils be shown these pests in place on the trees. They can study the effects of the insects upon the trees and they will be able to identify them if any appear upon their own shade trees and shrubbery at home.

The dragon fly, nymph and imago, is studied as a type of beneficial insect. The nymph can usually be scooped up with the mud from some pond while the imago can be seen on almost any field trip in the early fall. External structure must be studied, however, from alcholic material or dried specimens in glass cases.

The study of the grasshopper can be left until late in the season, since good living specimens can be obtained up to the time of heavy frosts. I usually have no trouble in picking from weeds and bushes on cool October mornings all of the specimens needed.

Along with these are usually found other members of the Orthoptera, true grasshoppers and walking sticks being notable examples. Theoretically, the study of the grasshopper as typical of insects in general in structure and physiology should be taken up as the first study of the course, yet this is impracticable since many of the forms of insect life have disappeared by the time an extensive study of the grasshopper could be finished.

The honeybee is the standard type insect representing the Hymenoptera. We have a hive of bees just outside the laboratory window which furnishes abundant material for study. The best season for observing the various activities going on in a beehive is May or June. Dr. Hodge's *Nature Study and Life* gives a full description of the possibilities of a bee colony in the schoolroom.

In every case where possible in the study of the insects the specimen should be studied alive. But preserved and dried specimens are necessary. Especially is this true in the case of complete life histories and with material to show damage done by insects. There must be a laboratory collection to supplement the material which can be picked up as needed for study. This calls for a suitable method of preserving and displaying specimens. The Riker mounts serve an excellent purpose, but they allow view from one side of the insect only. A case which serves the purpose better has glass on both sides, the two being kept apart at the proper distance by a frame made of thin strips of wood to which the glass plates are glued and the whole is bound with passe partout. The insect or other material is stuck to one of the glass plates with white shellac in any desired position. The method is described fully in *Nature Study and Life*, and more recently in Volume II of the *Nature Study Review*.

Most of the work of preparing mounts is work for the teacher and not for the pupil, since only in exceptional cases will a pupil make a respectable mount of a delicate specimen.

To be able to teach the subject of insects to the best advantage, the teacher must be thoroughly acquainted with his field. He must know where and when his material can be secured. It is a good plan to keep a diary as a guide for the work of future years. Every field trip with the pupils must have a definite purpose. The work should be discussed in class before the trip is made and after it is completed.

I am thoroughly convinced that the collecting which the pupils do should be done according to some definite purpose. It may

be for the sake of showing complete life histories, or for showing the relations of insects to plants, or by any other definitely organized practical plan. I am doubtful of the advisability of starting the pupils out to see what they can catch with no other purpose than that of getting a collection of "bugs." Pupils should be encouraged to bring home and into the laboratory living material by means of which life histories can be worked out. I am of the opinion that the pupil who brings in a caterpillar of the tussock moth and feeds it until it makes its cocoon and watches the female emerge and lay her eggs on the pupa case has gained more power and useful information than could be gained by the same individual by sticking pins through dozens of unfortunate specimens of insects taken at random and with no definite purpose in mind.

It has proved an excellent practice in the Senn High School to complete the study of insects with several charts which summarize, under various heads, the data which have been worked over in the class and in the laboratory and field. The pupils are aided in making these charts by bulletins, a supplementary text, and books from the library.

A Summary of the Study of Insects is intended to fix definitely the main characteristics of the eight or nine orders of insects which have been studied.

Insects Which Affect Man and Animals groups together the insects which carry disease or are pests affecting other animal life and lists useful information with regard to these forms.

Insects Injurious to Plants shows the economic relations of a select list of insects with regard to plants affected, damage done, and remedies.

Controlling Insect Pests deals specifically with the methods used in destroying insect pests.

The measure of a course is, to some extent, information stored up, but a better criterion includes power developed. The work with the study of the insects should aid in the development of a citizen alive to his own interests but also alive to those of the community.

"Fertilization is a substance which helps lay the eggs and give it its food."

"Weevils are animals which kill chickens at night."

"The ecliptic is the path of the sun upon the earth."

"A spectroscope is the condition a given light takes when it is separated into its constituent colors."

A GRAPHICAL SOLUTION OF THE EQUATION,

$$\frac{1}{A} = \frac{1}{a_1} + \frac{1}{a_2} + \ldots\ldots$$

By J. H. V. Finney,
University of Colorado, Boulder, Colo.

This equation occurs frequently in the solution of problems in physics and electrical engineering. For example the resistance of parallel circuits is given by

$$\frac{1}{R} = \frac{1}{r_1} + \frac{1}{r_2} + \frac{1}{r_3} + \ldots.$$

The total capacity C of condensers in series is

$$\frac{1}{C} = \frac{1}{c_1} + \frac{1}{c_2} + \frac{1}{c_3} + \ldots.$$

And the relation between focal length F, and the distances p and q, of an object and image, from the vertex of a mirror or lens, is

$$\pm\frac{1}{F} = \frac{1}{p} \pm \frac{1}{q}.$$

The following graphical method of solution, which was suggested by Problem 931 of Shearer's *Notes and Questions in Physics*, has proved useful to the writer and may be of interest to others. It is short, easily understood, and its accuracy can be made whatever the conditions of the problem may warrant.

A suitable arbitrary scale, as shown in Figure 1, is laid off along horizontal and vertical axes taken on a sheet of cross section paper ruled decimally. If both axes are laid off to the same scale, a line OB is drawn to make an angle of 45° with each, and the solution of the equation is accomplished as follows:

A straight edge is laid connecting the points (a_1, O) and (O, a_2). The ordinate (or abscissa) of the intersection of the straight edge and the line OB is the desired value of A.

Proof: The equation of the straight edge is

$$\frac{x}{a_1} + \frac{y}{a_2} = 1.$$

The equation of the line OB is

$$y = x.$$

Solving these simultaneous equations we get the intersection,

$$y = x = \frac{a_1 a_2}{a_1 + a_2},$$

which is the same as we get by solving for A in the equation,

$$\frac{1}{A} = \frac{1}{a_1} + \frac{1}{a_2}.$$

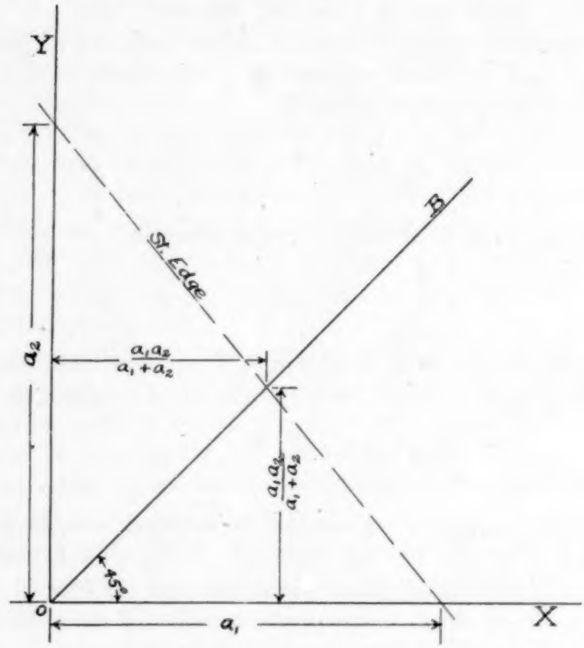

FIGURE 1.

To solve the equation,

$$\frac{1}{A} = \frac{1}{a_1} + \frac{1}{a_2} + \frac{1}{a_3} + \ldots . \frac{1}{a_n},$$

the straight edge is laid from a_1 on one axis to a_2 on the other. The intersection of the straight edge with the line OB gives us A_1, where

$$\frac{1}{A_1} = \frac{1}{a_1} + \frac{1}{a_2}.$$

Our equation now becomes

$$\frac{1}{A} = \frac{1}{A_1} + \frac{1}{a_3} + \ldots . \frac{1}{a_n}.$$

The straight edge is now laid from A_1 to a_3, and the intersection gives A_2 where

$$\frac{1}{A_2} = \frac{1}{A_1} + \frac{1}{a_3}$$

We proceed in this way until we have used all the n terms, which gives us the desired value of A.

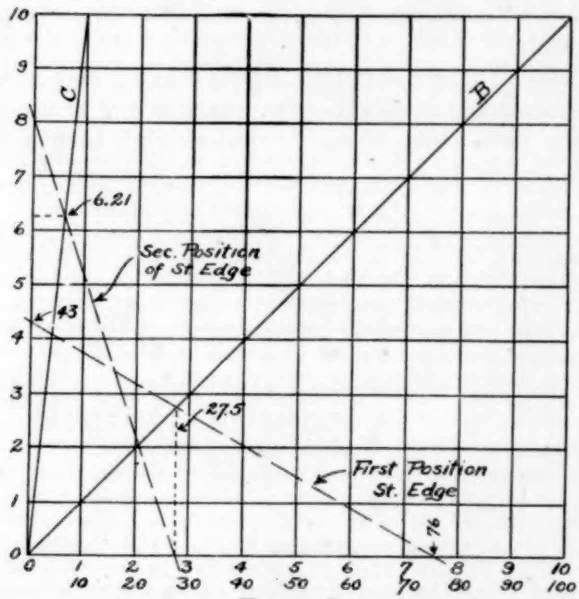

FIGURE 2.

It is evident the above is true when both abscissa and ordinate are multiplied by any number as 1/10, 10, or 100, making the same chart serve for all magnitudes.

If some values of a are of the order of ten times the magnitude of others, we may make the readings easier by the following modification:

The axis of abscissa is scaled from 0 to 10 and from 0 to 100, as shown in Figure 2. A second line OC is drawn through the points (O, O) and (10, 10), using the large abscissa scale. Now, in the equation,

$$\frac{1}{A} = \frac{1}{a_1} + \frac{1}{a_2},$$

if a_1 is of the order of ten times the magnitude of a_2, we find A at the intersection of the straight edge and the line OC, and the result is read on the ordinate scale. This is evidently true for the line OC has the same 45° slope as the line OB, it being drawn to a different abscissa scale.

Example: Find the resistance of three conductors in parallel which have respectively 43, 76, and 8 ohms resistance.

Solution: See Figure 2. Place the straight edge from 43 to 76 and the intersection of this with the line OB gives us 27.5 on the abscissa. Placing the straight edge from 27.5 to 8, the intersection with the line OC gives us 6.27 ohms, which is the desired result.

In the case of a lens or mirror, where F and q may have $+$ or $-$ values according to whether the image is real or virtual, our chart must have both $+$ and $-$ values, and such a chart is shown in Figure 3.

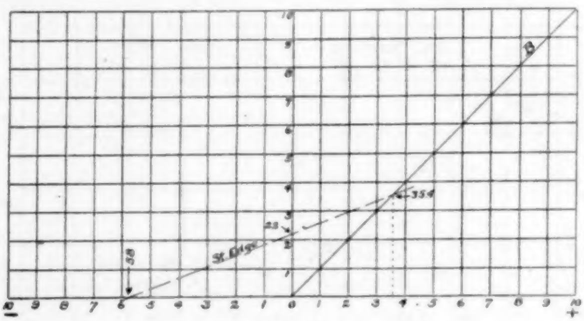

FIGURE 3.

Example: Find the focal length of a lens which, if an object is placed 58 cm. in front, gives a virtual image 22 cm. from the lens.

Solution: In this case F and q are negative, but if we change signs through the equation we may take F and q as positive and p negative. Placing the straight edge from -58 to 22 and prolonging until it crosses the line OB we find the desired focal length to be 35.4 cm.

MINERAL RESOURCES OF SOUTH CAROLINA.

The mineral resources of South Carolina are largely undeveloped and therefore the value of the annual production, amounting to about $1,500,000, is small as compared with that of most states. Clay, stone, and phosphate rock greatly exceed all other mineral products in value of production.

As a result of the war, many industries in the United States are being revolutionized, and this is especially true of the industries dependent on mineral products. American industries formerly using minerals imported from Europe are now almost entirely cut off from that source of supply. Certain of these minerals are known to occur in commercial quantities in South Carolina, and detailed investigation would probably result in the discovery of others. The demand for products, no longer obtainable abroad, makes it possible to work deposits in this country that were unprofitable under former conditions.

At present there is a serious shortage in the supply of two mineral products, pyrite (a sulphide of iron) and manganese ore, both of which are essential for the successful prosecution of the war. Virginia leads all of the states in the domestic production of both pyrite and manganese ore, but South Carolina is at least "doing her bit."

Most of the pyrite used in making sulphuric acid has in the past been obtained from Spain, and large quantities were imported into Charleston each year for use in the fertilizer plants of the state. The demand for sulphuric acid in the manufacture of explosives has increased enormously, and now we are receiving practically no pyrite from Spain. The shortage is being supplied in part by native sulphur from Louisiana and Texas, but this is much more expensive, especially where it is burned in a plant designed for the burning of pyrite. Recently one of the old gold mines of South Carolina was reopened and now it is producing pyrite. There are probably other pyrite deposits in the state which could be profitably worked under present conditions.

Manganese is essential in the production of high grade steel, and it is estimated that the domestic production for 1917 will amount to about six per cent of the ore needed. Between twenty and thirty ships are said to be engaged in bringing ore from Brazil. The shipping problem is growing more serious every day, and yet manganese ore must be obtained if steel making is to be continued at the present rate. Within the past year manganese deposits were opened up near McCormick, and recently it was reported that two carloads of ore were being shipped weekly. There may be other deposits in South Carolina.

There are inexhaustible supplies of kaolin, or white clay, in South Carolina. At present they are being used chiefly in the manufacture of paper, but a process of discoloring kaolin is now reported as successful, and this may make large deposits available for the manufacture of white ware and pottery. The value of clay, mainly kaolin, imported into this country from Europe and China during 1913 exceeded $2,250,000. Before the war much of the clay used in the manufacture of glass pots was obtained in Germany, but today it must all be obtained at home.—[*University News.*

MAY FIGHT PINK BOLLWORM IN MEXICO.

Discussing the present appearance in Texas of the pink bollworm, a highly destructive cotton pest, the Secretary of Agriculture, David F. Houston, writes in his annual report:

"It is planned to establish a cotton-free zone in Texas, approximately fifty miles in breadth, along the Mexican border. It is proposed not only to eliminate cotton culture in this area but also to eradicate all volunteer cotton. Similar zones will be established to include any infested areas in Texas or the other Southern States. Furthermore, the cotton grown on the Mexican side will be kept under observation, and the department will cooperate with the Mexican Government, local authorities, and plantation owners in stamping out any outbreaks within fifty miles of the border. If the assistance of the Mexican Government can be secured, a thorough survey will be made of all Mexican cotton regions to ascertain the present distribution of the insect. This survey ultimately would be the basis for determining the possibility of exterminating the pest in Mexico. It may appear that the most effective and economical method of preventing the further invasion of the United States by the pink bollworm will be to undertake this task. It would involve large expenditures, but the seriousness of the situation might amply justify them."

VALID AIMS AND PURPOSES FOR THE STUDY OF MATHEMATICS IN SECONDARY SCHOOLS.

By ALFRED DAVIS,

William and Mary College, Williamsburg, Va.

Chairman of a Committee of the Mathematics Club of Chicago Appointed to Investigate This Topic.

(Continued from the February number.)

7. *Mathematics Gives Ability to Handle a Tool, Essential in Much of Life's Work.*

Failure to recognize this often makes trouble for the student later. Prof. A. R. Crathorne, of the University of Illinois, says, "we have in the University of Illinois graduate students in agriculture who find themselves under the necessity of delaying the work in which they are directly interested in order to study the freshman algebra that they find essential to the study of their problems" (SCHOOL SCIENCE AND MATHEMATICS, vol. 16, p. 420). And further, "The utility of algebra as a medium of expression is on the increase as surely as we are gaining more exact scientific knowledge" (*Ibid.*). The list of courses for which mathematics is an essential prerequisite, as given by a committee of this club (SCHOOL SCIENCE AND MATHEMATICS, vol. 16, pp. 610-611) is as follows: scientific agriculture, engineering, physics, chemistry, art (drawing, designing, architecture, modeling, life and still life drawing, handicraft), pharmacy, dentistry, navigation, astronomy, naval and military engineering, domestic science, insurance, forestry, commerce and administration, railway administration, political economy, sociology, hygiene, sanitation, education, medicine, and journalism. Law and theology are included with some reservations. It is not difficult to see that a knowledge of algebra and geometry is absolutely essential for some of these courses, while in the others it has important uses, particularly the formula, the graph, and the equation of elementary algebra.

The man of ordinary education needs a knowledge of mathematics to appreciate everyday literature on many topics. Reading the many books and magazines relating to the automobile, the aeroplane, progress in science, or the war, without this as a foundation, is like reading about various places of interest without a knowledge of place geography. Prof. S. G. Barton, of the Flower Observatory, University of Pennsylvania (*Science*, vol. 40, p. 697) says that in the Encyclopedia Brittanica (11th

ed.) there are 104 articles which use the calculus, of which about one-fourth are pure mathematics. Some of these articles are: clock, heat, lubrication, map, power transmission, ship building, sky, steam engine, etc. There is much greater need for a knowledge of algebra and geometry in everyday reading. Prof. D. E. Smith, of Columbia, says, "Of the necessity for knowing number relations there can be no question, but fifty years ago one might well have cried the slogan abroad from the housetops, 'Will anyone tell me why the girl should study algebra?' Today a person would sadly feel his ignorance if he or she had to look with lack-lustre eyes upon a simple formula such as may be found in *Popular Mechanics*, *Motor*, the *Scientific American*, an everyday article on astronomy, a boy's manual on the airplane, or any one of hundreds of articles in our popular encyclopedias. These needs come not only within the purview of the boy; they are even more apparent in the case of the girl, she who is to have the direction of the education of the generation next to come upon the stage of action. Each must know the shorthand of the formula, and the meaning of a simple graph, of a simple equation, and of a negative number, or else must feel the stigma of ignorance of the common things that the educated world talks about and reads about." *T. C. Record* May, 1917.)

It is not enough that we aim at the application of the results which others have worked out. We must go deeper than that. An *intelligent* use of mathematics *demands* a knowledge of the subject. It is the testimony of a teacher in a correspondence school that a student can in a few lessons learn the application of a formula to a particular situation; but that when a new situation arises there is no resourcefulness to meet the new need. The student has not mastered the subject. His place in the industrial world must be that of a machine. A. R. Forsyth, President of the British Association for the Advancement of Science, Sec. A, says regarding the Perry movement, "Something has been said about the use of mathematics in physical science, the mathematics being regarded as a weapon forged by others, and the study of the weapon being completely set aside. I can only say that there is danger of obtaining untrustworthy results in physical science if only the results of mathematics are used: for the person so using the weapon can remain unacquainted with the conditions under which it can be rightly applied. . . . The results are often correct, sometimes incorrect;

the consequence of the latter class of cases is to throw doubt upon all the applications of such a worker until a result has been otherwise tested. Moreover, such a practice in the use of mathematics leads a worker to a mere repetition in the use of familiar weapons; he is unable to adapt them with any confidence when some new set of conditions arises with a demand for a new method: for want of adequate instruction in the forging of the weapon, he may find himself, sooner or later in the progress of his subject, without any weapon worth having." . . . "The witness of history shows that, in the field of natural philosophy, mathematics will furnish the more effective assistance if, in its systematic development, its courses can freely pass beyond the ever-shifting domain of use and application." (Perry's "Teaching of Mathematics," p. 36, and *Nature*, vol. 56, p. 377.)

The study of mathematics is useful in giving set and balance to one's life. The more widespread its study and the resulting mathematical sense the less opportunity there will be for dishonest practices by the unscrupulous man of affairs; a sort of intuitive sense of the correctness of business transactions will often prevent errors and losses; the elements of chance and luck will play a less important part in our affairs and superstition, the stronghold of ignorance blocking the way of progress, will be demolished.

8. *Mathematics Gives Training in the Use of a Symbolic Language.*

Much of the world's work is done by the use of symbols. They are the tools for rapid thinking and writing. The progress mankind has made would be impossible without them. We are convinced of this when we think of carrying on the simple operations of multiplication and division without the use of figures. Newton's law of gravitation: $F = GMm / D^2$, where F is the force acting between two bodies, M and m are the masses of the bodies, D the distance between their centers, and G the constant of gravitation, would be cumbersome indeed if it were necessary to say it the long way in order to use it. By the use of the algebraic symbols the whole story is gotten at a glance, and in a form convenient for application to other problems. There is economy of mental effort as well as of time. The importance of symbols is further illustrated in the fact that Newton chose a clumsy system of notation for the calculus while Leibnitz chose the present system, which is much better. The English adopted Newton's method and so fell far behind the

mathematicians of the continent in development and application of the calculus. A reprint from the *Engineering Supplement* of the *London Times*, June 19, 1910, says, "The extent to which mathematics is capable of exact prediction depends on expressing the problem in mathematical language. The greater ability of engineers of today to translate problems into this language has led to an increasing number of successful inventions." The interpretation and application of formulae is necessary in the reading of all sorts of current literature, and in the application of general principles to all sorts of human effort. Algebra and geometry offer unequaled opportunity for the mastery and use of symbols, since the solution of problems requires constant translation back and forth. Dr. Smith (*T. C. Record*, May, 1917), "One merit of mathematics no one can deny—it says more in fewer words than any other science in the world." (*The Nation*, vol. 33, p. 426), "The human mind has never invented a labor-saving machine equal to algebra." Lack of training in the use of symbols fixes very narrow limitations to one's life.

The graph has become one of the most important symbols in modern life. The meaning and use of the graph cannot be properly taught apart from algebra. We see at a glance the relationship of two interdependent variables at any stage. Prof. Crathorne (School Science and Mathematics, vol. 16, pp. 423-4) says, "The world is full of variables which depend on other variables, presenting to us the problem of finding out and exhibiting the manner of dependence. The office of the graphical methods of algebra is to exhibit this dependence to the eye, and not, as many textbooks would imply, merely to aid in the solution of equations. . . . In a recent book for workingmen in shop mechanics, a full page is devoted to an explanation of the stretch of copper wire for different loads. The author, no doubt realizing the vagueness of his explanation, then clearly sums up by a graph with three lines of English under it." The graph has become well-nigh indispensable in presenting statistics. Much labor is necessary to get facts from numerical data, while the graph gives the same information almost without effort and presents a picture to the mind that is easy to recall. The graph makes the function concept clear to the pupil. He is able to understand the meaning and something of the importance of "x is a function of y." When the graph is subject to a known law, as represented by an equation, it is a necessary step to the study of advanced mathematics.

Regarding the saving of mental energy by a knowledge of mathematics, and by a mastery of the use of its symbols, Prof. Chas. H. Judd, of the University of Chicago ("The Psychology of High School Subjects," p. 131) says, "No student will know what mathematics is until he realizes the great economy of mental energy which this form of experience makes possible."

9. *Mathematics Develops the Imagination.*

G. St. L. Carson, in "Mathematical Education," p. 41, says, "The operations and processes of mathematics are in practice concerned at least as much with creations of the imagination as with the evidence of the senses." F. J. Herbart says, "The great science (mathematics) occupies itself at least just as much with the power of imagination as with the power of logical conclusion." Prof. H. H. Horne, of Dartmouth College, says, "Apart from its manifold applications, mathematics is the inevitable disciplinary element in the curriculum. It trains in the habit of logical and symbolic thinking, of precision and concentration, and it develops the imagination." The concepts of space and number relationships are fundamental in education. Col. F. W. Parker ("Talks on Pedagogics," p. 50, etc.) says, "I think we can truthfully say that form is the supreme manifestation of energy, and without a knowledge of form and without the power to judge form with some degree of accuracy, there can be no such thing as educative knowledge. . . . Form and number are modes of judging and are necessary to a knowledge of the external world. . . . The study of form and geometry are of fundamental, intrinsic importance in education." In the study of mathematics, images of one, two, and three dimensions are constantly before the mind. At first, objects and drawings are used to give clear pictures, but the student soon learns to depend on the imagination to reproduce the images and to frame new relationships. This is especially true in the study of geometry. In the discussion of a problem, all the possibilities of a given case must pass in order before the mind. Surely the imagination is used and cultivated in the study of mathematics.

A few well-selected problems in physics and astronomy, taught with appreciation by the teacher, will aid in the cultivation of the imagination and broaden the life of the pupil. These may relate to the velocity of light and the length of its wave; the relative sizes of the planets and stars and how these are measured; the distance of the planets and stars and the meaning of "light years"; etc. Experience shows that problems relating

to such topics are fascinating to the student. Carson ("Math. Ed.," p. 10), says, "One of the few really certain facts about the juvenile mind is that it revels in the exploration of the unknown." Astronomy, in particular, leads the mind to the threshold of the unknown, and exposes it to the Infinite. Who can be little, or narrow, or prejudiced, if his imagination has been inspired by mathesis!

10. *Mathematics Leads to a Knowledge and an Appreciation of the Foundations of Science.*

All science is ultimately mathematical in its methods; the more completely it is developed the more mathematical a science becomes. Mathematics enables us to apply accepted laws to Nature's problems. In this way Newton's and Kepler's laws have been established and have been made to extend to almost infinite reaches into space and to unfold the mysteries of a universe of which we are an infinitesimal part. Astronomy was astrology until mathematics released it and it became a science. But even astrology depended somewhat on mathematics. Sir John Herschel ("Outlines of Astronomy," Introduction, Sec. 7) says, "Admission to its sanctuary (astronomy) and to the privileges of a votary is only to be gained by one means, *sound and sufficient knowledge of mathematics, the great instrument of all exact inquiry, without which no man can ever make such advances in this or any other of the higher departments of science as can entitle him to form an independent opinion on any subject of discussion within their range.*" It is through mathematics that we are gaining knowledge of molecules, atoms, electrons, ions; of the wonderful changes that are occurring in these and of the laws that govern them. Mathematics has well-nigh unlocked the secret of matter itself. Indeed, we could know little of chemistry, physics, or of any other science were it not for the aid of mathematics; witness the following testimony: Roger Bacon ("Opus Majus") "Mathematics is the gate and the key of the sciences. . . . Neglect of mathematics works injury to all knowledge, since he who is ignorant of it cannot know the other sciences or the things of this world. And what is worse, men who are thus ignorant are unable to perceive their own ignorance and so do not seek a remedy." Kant, "A natural science is a science only in so far as it is mathematical." Laplace, "All the effects of nature are only mathematical results of a small number of immutable laws." W. W. R. Ball ("History of Mathematics," p. 503) "The advance

in our knowledge of physics is largely due to the application to it of mathematics, and every year it becomes more difficult for an experimenter to make any mark in the subject unless he is also a mathematician." Comte, "All scientific education that does not begin with mathematics is defective at its foundation. . . . In mathematics we find the primitive source of rationality; and to mathematics must biologists resort for means to carry on their researches." J. F. Herbart, "It is not only possible but necessary that mathematics be applied to psychology; the reason for this necessity lies briefly in this: that by no other means can be reached that which is the ultimate aim of all speculation, namely *conviction*." Novalis, "All historic science tends to become mathematical. Mathematical power is classifying power." Prof. A. Voss, of the University of Munich, in a lecture in 1903 (quoted by T. E. Mason of Purdue in *Science*, December 15, 1916) said, "Our entire present civilization, as far as it depends upon the intellectual penetration of nature, has its real foundation in the mathematical sciences." Prof. Thos. E. Mason (*Science*, December 15, 1916), "Can you realize what would happen, just what stage of civilization we should be in, if all that is developed by the use of mathematics could be removed from the world by some magic gesture? Every branch of physics makes use of mathematics; chemistry is not free from it; engineering is based on its development; sociology, economics, and variation in biology make use of statistics and probability. Our skyscrapers must disappear; our great bridges and tunnels must be removed; our transportation systems, our banking systems, our whole civilization, indeed, must step back many centuries." The student who leaves high school without a knowledge of the importance of mathematics in science has a serious lack. Problems in algebra and geometry should, when convenient, relate to the various sciences. If the text does not furnish such problems the teacher should provide them.

11. *Mathematics Should Be Appreciated as One of the Greatest Achievements of the Human Intellect.*

In this respect there is the same reason for studying mathematics as for studying literature, language, art, or history, for it is only as we learn to appreciate the greatest in man's efforts, achievements, and aims that we can have the proper ideals and purposes in our lives. It is only through this knowledge and appreciation that one is able to take an intelligent part in the

world and in the age in which one lives; that one can be a live force and not an encumbrance in the world. The path by which men have traveled is shown by history; literature and art beautify its borders; language furnishes the bond of unity; but science, including mathematics, is the pavement and even provides the light by which they walk. Indeed, mathematics is the greatest of the sciences. Hermann Hankel says, "In most sciences one generation tears down what another has built and what one has established another undoes. In mathematics alone each generation builds a new story to the old structure." The earth as the center of the universe, the corpuscular theory of light, the indestructibility of the atom, these and many other theories, at one time considered fundamental, are now fit only for the intellectual museum; but the contributions to mathematics endure. Dr. Smith (*T. C. Record*, May, 1917) says, in speaking of the theorem of Pythagoras, "Before Mars was, or the earth, or the sun, and long after each has ceased to exist, there and here and in the most remote regions of stellar space, the square on the hypotenuse was and is and ever shall be equivalent to the sum of the squares on the sides. All our little theories of life, all our childish speculations as to death, all our trivial bickerings of the schools—all these are but vanishing motes in the sunbeam compared with the double eternity, past and future, of such a truth as this." Surely we can appreciate Laisant when he says, "Mathematics is the most marvelous instrument created by the human mind for the discovery of truth"; and Leibnitz, who says, "Mathematics is the glory of the human mind."

Do we aim, as teachers, to give this appreciation of mathematics? It can be accomplished only by the study of mathematics, and not by a course *about* mathematics, as some have suggested. As well expect nourishment from talking about food as to expect knowledge and appreciation of mathematics from talking about it. More importance ought to be given the history of mathematics in our teaching. Much inspiration and enthusiasm can be gained from the lives of great mathematicians. And at appropriate times there should be given the student a prospective view of the richness and beauties of the subject to be realized by advanced study.

12. *Mathematics May Make An Important Contribution to the Aesthetic, Moral, and Religious Life of the Individual.*

Henri Poincaré (*Annual Report*, Smithsonian Institution.

1909) says that mathematics has aesthetic value in the feeling of elegance in a solution or demonstration; in the harmony among parts, their happy balancing, and their symmetry. The feeling of elegance may come from unexpected associations and kinships among things. The sense of beauty is bound up with the economy of thought. We have seen high school pupils fascinated by the application of the binomial theorem; by the power and elegance of an algebraic solution; or by the Golden Section and other geometrical constructions. They are delighted with beauties in nature and art that are revealed for the first time through the study of algebra and geometry. Prof. S. G. Barton (*Science*, vol. 40) says, "Beauty is concealed by ignorance of the mathematics necessary for its interpretation. The student of mathematics will see that of which the untutored mind has no conception, because lying beyond its comprehension. . . . One of nature's demands in which she is inexorable is a study of higher—the highest—mathematics. The interpretation of her laws requires it.

"The massive bridge once wonderful because of its enormous size, when its principles of construction are understood, becomes a thing of beauty, a wonderful monument to the intellects of the designer and the constructor. The great tunnels, turbines, subways, are changed to objects of wonder, to those capable of understanding the difficulties overcome in their construction. The stars in the universe above, which nightly dissipate some of their light upon the earth, bespeak their Creator's glory in voices but faintly heard by those whose training does not enable them to comprehend the reign of law there prevailing. To such an one 'the heavens declare the glory of God' in a more real and exalted sense." Thus mathematics literally opens a new earth and a new heaven to us. It unlocks for us the "music of the spheres"; it reveals the thoughts of the Eternal.

The study of mathematics leads to clear thinking; to honest and patient effort; to reverence for truth; and must, therefore, have a large place in the building of character. B. F. Finkel says, "Mathematics is the very embodiment of truth. No true devotee of mathematics can be dishonest, untruthful, unjust. Because, working with that which is true, how can one develop in himself that which is exactly opposite? Mathematics, therefore, has ethical as well as educational value." Prof. H. E. Hawkes, of Columbia (*Mathematics Teacher*, March,

1913) says, "What is simplest and most beautiful in the domain of pure mathematics too often corresponds to the facts of nature to be accidental. I contend that it is our privilege to point out, at every possible turn, this coordination of number and form, of formula and physical law, of unity between mind and nature. This is an experience of no mean moral value, to realize that our mathematical procedure is attuned to the harmony of the universe." In mathematics, then, the human mind relates itself to the Supreme Intelligence, whose thought is manifest in the universe; and the contact must leave its imprint on our lives. This leads us to the consideration of the religious value in the study of mathematics.

Man has an innate desire from early years to reach towards the Infinite and the Eternal. Clerk Maxwell, towards the end of his life, said, "I have looked into most philosophical systems, and I have found that none of them will work without God." Mathematics reaches farther and with greater certainty than any other philosophy; towards a Supreme Being, a great First Cause. It looks down the vistas of the ages past; and into the dimness of the eons to come; and the human mind is awed by the sublime majesty of the Divine. Prof. D. E. Smith says, "The proper study of mathematics gives humanity a religious sense that cannot be fully developed without it. . . . In the history of the world, mathematics had its genesis in the yearning of the human soul to solve the mystery of the universe, in which it is a mere atom. . . . It seems to have had its genesis as a science in the minds of those who followed the course of the stars, to have had its early applications in relation to religious formalism, and to have its first real development in the effort to grasp the Infinite. And even today, even after we have been pushing back the sable curtains for so many long centuries—even today it is the search into the Infinite that leads us on." Col. Parker ("Pedagogics," p. 46) says, "I can assert that, from the beginning, man's growth and development have utterly depended, without variation or shadow of turning, upon his search for God's laws, and his application of them when found, and that there is no other study and no other work of man. We are made in His image, and through the knowledge of His laws and their application we become like unto Him, we approach that image." . . . "There is but one study in this world of ours, and I call it, in one breath, the study of law, and the study of God." That the study of mathematics is the study of

God's laws and so must lead to God there can be no question. Plato, "God eternally geometrizes." C. J. Keyser says, "Again it is in the mathematical doctrine of invariance, the realm wherein are sought and found configurations and types of being that, amid the swirl and stress of countless hosts of transformations, remain immutable, and the spirit dwells in contemplation of the serene and eternal region of the subtle law of Form —it is there that Theology may find, if she will, the clearest conceptions, the noblest symbols, the most inspiring intimations, the most illuminating illustrations, and the surest guarantees of the object of her teaching and her quest, an Eternal Being, unchanging in the midst of the universal flux."

> "And reason now through number, time, and space
> Darts the keen lustre of her serious eye;
> And learns from facts compar'd the laws to trace
> Whose long procession leads to Deity."
> —Jas. Beattie, "The Minstrel," Bk. 3.

No wonder the mind is fascinated by the fields opened through the study of mathematics. One is led to a spirit of reverence when he contemplates the human intellect as revealed in the ever unfolding and almost limitless range of mathematical achievement. It reveals and inspires Godlikeness. Mathematics deals with the eternal verities: it is, if you will, the majestic mountain peak that rises in sublimity above the clouds of doubt and uncertainty and basks in the sunlight of eternal truth.

These values in the study of mathematics will suggest the more important aims and purposes for its study and its teaching. The teacher will do well to have them in mind as a background for his teaching; in this way they will permeate and vitalize his work. But this is not enough. The pupil must also appreciate their importance, to give sufficient motive for his work, to satisfy him that the study is worth his effort. Not all pupils will appreciate these to the same extent. The teacher should ascertain the interests of the student and make the appeal chiefly in accordance with these interests. Bertrand Russell says, "Every great study is not only an end in itself, but also a means of creating and sustaining a lofty habit of mind; and this purpose should be kept always in view throughout the teaching and learning of mathematics." The same is true of all purposes; neither teacher nor student should work blindly without knowing what to expect as a result of his effort.

We have made our defense for the teaching of mathematics in high schools when we have shown that some of these values

can be realized alone by the study of mathematics, and that others can be realized better through mathematics than by the study of any other subject. We have shown that mathematics is most important in its culture values—that it is indispensable to everyone who would live his best. We might add the words of President Hadley of Yale, "The value of an education largely consists in studying facts that will not be used in after life, by methods that will be used." Dr. Snedden, of Teachers College, recognizes the fact that the chief claim for the study of mathematics is on the cultural side. In "Problems of Secondary Education" (recently published), p. 223, he says, "I am convinced that the prominence of algebra (and geometry) in secondary education rests not so much upon faith in its usefulness as a tool of further learning as upon belief in its value as a means of 'mental training' and upon the faith that somehow a knowledge of algebra is essential to general culture." Again (p. 229), speaking of a secondary school curriculum, he would "Seek to develop a 'culture' course in mathematics which should prove attractive to students seeking to inform themselves about the world in which they live; this to include some account of the evolution of mathematics as a human tool and as a means of interpretation, as well as a survey of modern applications of mathematics to the understanding of the universe and to the work of the world. Just as many of us can respond to operas, epics, and great paintings without being artists in these fields, so I think many could be led to appreciate the place of mathematics without becoming mathematicians." In the light of what we have said, we would change "should prove attractive," to "should be made attractive," throwing responsibility upon the teacher. We would *require* a course in mathematics of everyone. We would make this course to include the actual study of mathematics; for while we would not seek to make mathematicians of all students, in the sense of making each a specialist, everyone needs to study mathematics as well as to study *about* it. And further, the cultural value of mathematics is of immeasurably greater importance than the mere getting of information about things. However, a knowledge of mathematics is essential in much of life's work; and it is evident that it will become more and more important as a means of investigation in practically every field of endeavor.

Let us remember, withal, that the greatest values and aims in the study of any subject, like all the greatest things in life,

cannot be easily reduced to exact measurement. We have heard Dr. Smith say that he wished someone might measure the value of the early study of Greek in his life. So far no one has, and it is not likely that the psychologist ever will invent a measure for such values. Therefore, while we satisfy ourselves and seek to satisfy others by giving reasons for our faith in, and enthusiasm for, the subject we teach, we do not hope to close the door to the questions of doubters and critics. Nor do we think the door can ever be closed or ever should be. It is the glory of mathematics that, while it has had destructive critics through the centuries, it has survived them all and is marching steadily onward to a higher and a surer place in our civilization. Like everything worth while, it has its critics and enemies, but these ultimately contribute to its strength. They aid mathematics in leading its advocates to establish more firmly its claims, to adjust it better to changed conditions; and they are the means of heralding its worth to the multitude. This is the logical outcome of present criticism.

(To be Continued)

VALUABLE TOPOGRAPHIC MAPS.

Comparatively few people realize the value of the topographic maps which are being published by the Government. There is no state some of whose area has not been covered by these topographic surveys, the resulting maps of which convey more useful information of their areas than any other maps. They portray accurately the physical features of the country, the hills and mountains, valleys and slopes, streams and swamps, as well as every work of man, such as railroads, wagon roads, bridges, and houses and other buildings. A single feature of the map which makes it well worth having is that it shows the altitude or elevation of every point in the area; it is a detailed dictionary of altitudes.

The maps are printed in three colors, black being used to indicate houses, roads, names of towns—the human features of the map—blue to indicate the streams and lakes and other water features, and brown to indicate the valleys and hills, whose elevations are shown by means of contour lines. Some of the maps are printed with a fourth color, green, which is used to show woodlands. The topographic map is in fact an accurate relief model of the area mapped.

The maps are in increasing demand not only by engineers, for whom they constitute base maps of the greatest value in planning all construction work, but by automobilists, hikers, and farmers whose homes are included in the areas. The Geological Survey, Interior Department, has already published 2,500 topographic maps, covering more than forty per cent of the United States. About 20,000 square miles of new country is surveyed annually, resulting in the publication of approximately one hundred new maps a year.

THE INTRODUCTION OF DEMONSTRATIVE GEOMETRY.[1]

By Ernest B. Lytle,
University of Illinois.

"When you come to the geometry class you must leave your common sense behind," is the most astounding statement that I have ever heard a teacher make to students. Some time ago I was visiting a geometry class in one of the larger high schools of this state. The class was in the first week of geometry study; after the class had gone through formally the usual proof of one of the earlier theorems, a bright youngster remarked, "I don't see the use of all that talk. I knew that theorem was true before by my common sense." Then came this most startling statement from the teacher, "Fred, when you come to the geometry class you must leave your common sense behind." No wonder there was great mental confusion and little, if any, interest evident in that room.

I was introduced to demonstrative geometry by an attempt to prove the obvious theorem, "All straight angles are equal," and remember my distress at the fuss made over the truth of so simple a statement when its truth seemed to me self-evident to anyone with ordinary sense.

These are not uncommon experiences, judging from the many people who tell of the long time it took them to see just what the purpose and value of geometry was. Just this week an excellent teacher told me he believed that success or failure in geometry was very largely determined by the character of the first few weeks' work in the subject. Widespread dissatisfaction with the old formal methods and appreciation of the importance and difficulty of a good introduction to demonstrative geometry have roused interest in the question before us for discussion, "What is an effective way to introduce class work in geometry?"

Before beginning a course in demonstrative geometry it is desirable that the students take some preliminary work in observational geometry. For example, such a course as that in concrete geometry recommended by the N. E. A. Committee of Ten on Secondary Studies (Report 1894, p. 110), or as that given in Hedrick's little book on *Constructive Geometry* (Macmillan Co., 1916). But since such courses are found in few of our schools we will assume in this discussion no more preliminary

[1]Read before the November, 1917, Conference of High Schools with the University of Illinois.

work in geometry than that which is gotten from drawing courses, arithmetic, and general daily experience. We will assume further that the work here outlined is for the ordinary class of second-year high school students, since demonstrative geometry is usually begun in the second year in most of our high schools. We offer no arguments for an informal beginning since there is quite a general agreement that such an introduction is necessary. That this need has long been appreciated in Germany, France, and Italy is shown by the numerous preliminary, or "propaedeutic," courses offered in their elementary and secondary schools, such as those outlined by Veronese, Holzmuller, and Simon, and by the able discussions of the merits of such courses as found in Reid's *Anleitung Zum Mathematischen Unterricht* (Berlin, 1906), in Schotten's *Inhalt and Methode des planimetrischen Unterricht* (Leipzig, 1890), and in Simon's *Methodik Des Rechnens und der Mathematik.*

There are three aims in this preliminary work: (1) to review, clarify, and informally develop from previous experience the fundamental notions of geometry; (2) to introduce the technical language of geometry, and (3) to create a feeling of need for proofs by slowly bringing students to the point of searching for reasons. We are too apt to forget that students beginning geometry already have much geometric knowledge which only needs to be clarified and translated into the technical language of geometry. Further, students will never appreciate what "geometry is all about" until they feel a real need for seeking reasons. The old and, unfortunately, too often the present practice of beginning by attempting to prove statements which seem perfectly obvious makes the whole subject of geometry seem trivial to the students and discourages interest. Carson well says, "one of the few really certain facts about the juvenile mind is that it revels in exploration of the unknown, but loathes analysis of the known" (*Mathematical Education*, Ginn & Co., 1913, p. 10). Klein is thinking of the same quality of the juvenile mind when he says, "At the beginning I pay no attention whatever to proofs, but am satisfied with the 'Behold' of the Hindus, until by very slow degrees I have brought my pupils to the point of searching for reasons" (*Jahresbericht der deutsch, Math. Ver., 1904*).

What principles will guide us in attaining these aims? (1) There must be either a direct or an indirect basis of sense perception: (2) that which is new or general must be made

real by application to or connection with past experience; (3) the method must be that of analysis and induction rather than deduction; (4) there must be motivation through the early creation of a desire to find reasons for beliefs.

"There is nothing in the understanding which has not been first in the senses," is an old pedagogical maxim. Any idea we have if carefully analyzed may be run back to sense perceptions. This basis is shown by the difficulties in the education of such defectives as Helen Keller. So there must be some use for models and figures in beginning geometry as well as some measuring of lines and angles. But care should be taken not to overdo this work. Dewey says, "It is foolish to insist upon the observation of objects if the student is so familiar with the objects that he could just as well recall the facts independently" (*Democracy and Education*, p. 185). Frank H. Hall used pins stuck into flat cushions to give his blind students something in place of our figures. He said his blind students would use his pincushion figures only a few days because by that time they could imagine the figures and thought the pincushions a nuisance. It is deadening to interest to continue the use of models and concrete work beyond the point of usefulness. Basic sense perceptions are necessary in new experiences, but their continued use in familiar situations is both distasteful and detrimental.

"Vague generality" is a common term of criticism. General terms and general statements too frequently lack reality and do not carry meaning. Students seldom feel the need of following up definitions with one or two concrete illustrations or special cases. Teachers generally fail in developing the habit of illustration in their students, which habit is necessary evidence of reality or true comprehension.

Since textbooks in geometry almost universally present proofs in the deductive form there is grave danger that students will fail to see the true methods of originating proofs. Their great difficulty with originals is evidence of a lack of training in methods of attack or discovery. Have your students ever said, "Yes, I understand that proof and see that it is all true, but how did the author ever think of doing it that way?" Failure to develop the analytic and inductive methods of attack and too early emphasis upon deductive forms tends to simple memorization of proofs originated by others. "Scientific method applied to the teaching of solving mathematical problems means the method of discovery, the method of induction, the method of

analysis" (*Scientific Method*, F. W. Westaway, p. 412). Deduction is the method for presenting final results where the false starts, the wrong suggestions, the study of special cases, and the unsuccessful trials of discovery have been left out; in presenting proofs in deductive form all the scaffolding of discovery has been removed. If students see only polished deductive proofs in the textbooks, and neither originate a proof by themselves nor witness the teacher discover a proof, there should be no surprise at their lack of ability in the discovery of proofs.

As suggested at the beginning of this paper, the first great difficulty in beginning demonstrative geometry is to make the students see the purpose of it, to make them feel what we are driving toward. The poorest possible beginning is in attempting to prove theorems which seem obviously true to the students. We should early make them see that we are trying to give valid reasons for our beliefs about geometric things. Simply stated, a proof consists in the production of facts as sufficient reasons to support some conclusion, implicitly challenging a denial of either the truth or the relevance of these reasons. The first step is to get the students to make some statements which they believe to be true about some figures they have drawn; these can be brought out by good questions from the teacher. The second step is to call for reasons for their belief, and the third step is for the teacher to attack and show insufficient some reason given. In the beginning, obvious reasons should be accepted without discussion, meanwhile watching for an incorrect reason to attack. Probably the first wrong inference will be that some lines are equal or parallel because they look equal or parallel. That appearances are often deceptive may well be shown by certain optical illusions, which the teacher keeps at hand for such purpose. (See *1908 Proceedings of the Central Association of Science and Mathematics Teachers*, p. 177, and Wentworth-Smith *Plane Geometry*, p. 15, for useful optical illusions.) Likewise measurement always appeals to beginners as a good reason for the truth of equalities in geometry. Although often using measurements to suggest truths, yet students must early be convinced of the difficulty of making accurate drawings, that measurements are at best only approximations, and that more simple and precise tests for equality are needed. The writer feels that the difficulty of making accurate measurements, their approximate character, and the feeling of repulsion which the abler students manifest for too much measuring, is not sufficiently

appreciated by teachers. In an informal, conversational way students can be led to see weakness in their old methods of reasoning and to feel a need for better reasons for their beliefs; under a little skilful guiding they soon find delight in seeking reasons for their beliefs which will stand up against all attacks upon either their truth or relevance. Only after the students have attained some appreciation of the purpose of proofs should they be led to put their final results into the formal, precise, and elegant deductive form.

Having considered general principles, we shall now give them concrete application. The students should come to the first class provided with paper, pencil, ruler, compass, and protractor. Through oral directions teach the following constructions:

(1) To bisect a given line segment.
(2) To bisect a given arc of a circle.
(3) To bisect an angle.
(4) To erect a perpendicular to a line at a point in the line.
(5) To drop a perpendicular to a line from a point without the line.
(6) To trisect a right angle.
(7) To inscribe a circle in a triangle.
(8) To pass a circle through three points not in a straight line.
(9) To draw a line parallel to a given line through an exterior point.

Make no attempt here to give the usual proofs of these constructions; if students question their truth give them approximate verification by measurement. Next have the students write a description of each construction in a notebook. Thus for (3) they would write something like the following:

To bisect any triangle BAC.

With A as a center and any radius r, describe an arc intersecting the angle sides in M and L. With M as a center describe an arc of a circle; with L as a center, and with the same radius describe another arc intersecting the latter arc in a point K. Join K to A and the line AK is the required bisector.

While learning these constructions and writing up their descriptions the students are introduced to the symbolism of geometry; they learn how to read lines and angles; use the simpler single letter notation wherever possible. While this work is being done in class periods under the direction of the teacher, assign for home work related construction problems, such as,

"Construct a square," "Inscribe a square in a circle," "Construct an inscribed hexagon by bisecting the sides of an inscribed triangle," etc. Geometric designs involving the fundamental constructions may be used for home work. (Hedrick's *Constructive Geometry* will suggest home work to the teacher.)

During all this work the teacher should have before him a list of geometric terms which he expects to fix in the students' minds; such as point (having position only), straight line (length only, no breadth or thickness), plane, solid, rectilinear figure, parallel lines, curves, circle, radius, diameter, chord, angle, right angle, acute, obtuse, complement, supplement, interior, exterior, vertical angles, bisect, trisect, etc. Develop the meaning of each of these terms by means of questions and illustrations; ask the students to point out examples of these terms on their figures; ask them to find examples in objects about them; translate old expressions, like "corners fit," "square corner," etc., into geometric language; compare their definitions with dictionary and text definitions; make these terms meaningful by continued and careful use. The originality and questioning skill of the teacher will direct this work of fixing fundamental notions and correlating them with their daily experiences.

If we are to avoid attempting to prove that which seems obvious to the students, there must be a broader foundation of assumptions than is common in beginning geometry. So the teacher should also have before him a carefully prepared list of obvious geometric facts which he expects to use as assumptions in later proofs, such as the following: (1) All straight angles are equal; (2) All right angles are equal; (3) The shortest path between two points is the line segment joining the points; (4) Two distinct points determine a straight line; (5) Any side of a triangle is less than the sum of the other two sides; (6) A diameter bisects a circle; (7) A straight line intersects a circle at most in two points; (8) Complements (or supplements) of equal angles are equal; (9) Two lines parallel to the same line are parallel to each other, etc. (The introductory chapter in Young and Schwartz's, or Wentworth-Smith's *Geometry*, or the *Report of the National Committee of Fifteen on Geometry*, p. 20, will assist a teacher in making such a list of fundamental geometric assumptions.) In most cases the emphatic statement of these fundamental facts is sufficient to bring conviction of their truth: informal discussion will bring acceptance of the truth of all; draw figures illustrating these fundamental facts; seek illustra-

tions in everyday experiences. After oral discussion has fixed these facts they should be carefully listed in the students' notebooks for future reference.

In order to make progress toward proving theorems, next develop with the class proofs for the simple theorems: (1) Vertical angles are equal; and (2) The bisectors of vertical angles form one and the same straight line.

Next take up the construction of triangles, from given data, as from two sides and their included angle, considering the usual four cases. Consider also their application to right triangles with necessary modifications in statement.

From this consideration of triangle construction make the transition to the formal proofs of congruent triangles as given in most texts, and begin from this point on to make use of the textbooks. By certain judicious omissions it is believed that this introductory oral work can be here connected up with any one of the textbooks now in common use.

Within the space here available, it is impossible to give all the details of the plan for introductory work here presented, but it is hoped that enough suggestions have been given to enable the teacher to complete all the details and adapt the scheme to his particular class and text. The length of time given to such an introduction must be determined by the preparation and the particular needs of each class. It may be quite short if students have had preliminary courses in constructive or concrete geometry. The prolonging of such informal work when not needed will tend to disgust the abler students.

The writer knows of no text on demonstrative geometry which gives a sufficiently informal introduction, and doubts whether such work can be put into a text with as effective results as when presented in class by the teacher. Some texts (Wentworth-Smith, Wells-Hart, Young-Schwartz, Long-Brenke, for illustration) however have greatly improved the introductory work.

This is one way of introducing demonstrative geometry. I hope the suggestions will assist the skilful teacher in making the study of geometry real, interesting, and valuable.

THE RELATION OF HIGH SCHOOL CHEMISTRY TO GENERAL CHEMISTRY IN COLLEGES.[1]

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In teaching general chemistry in colleges we cannot ignore the fact that a considerable portion of our students have studied chemistry in high school or preparatory school and that this elementary training will have an influence on their advancement. There is no doubt that we can teach these students more chemistry than beginners. But it is a problem to determine the exact advantage they may have and what credit may be given to their previous study of the subject.

This problem affects the colleges more seriously than the high schools, since a very small percentage of the high school graduates enter college and less than half of these have offered chemistry as an entrance subject. In an indirect way, however, it does have an important bearing on high school chemistry. If we cannot take high school graduates and use their knowledge of chemistry as a basis of a more advanced course, there is something radically wrong with their elementary training. And when I say this I would not have you think that high school chemistry should be *taught* as a preparatory course to future chemistry in college. In fact our elementary science courses in colleges, as well as in secondary schools, are frequently to be criticized because we look upon our pupils as future scientists and may teach them little that is of general educational value.

Those who teach elementary science in college are naturally inclined to consider that the ideal methods of teaching high school science are those that are miniatures of their own pet schemes. But we should expect high school students to come to us with a training meant to fit them for after life. It is the duty of the high schools to supply this and, if we put them in an advanced course in general chemistry, it should be one based on this idea. It is the only logical basis for such a course and probably the best that the high schools could possibly give us.

Very few colleges give two distinct courses in general chemistry, one for beginners and one for men who have already had an elementary training in the subject. Columbia has such an arrangement. At Harvard I believe the laboratory work is different. At Princeton we have different quiz groups, the lab-

[1]Part of an address before the Chemistry Section of the New Jersey Science Teachers' Association at Newark, December 9, 1916.

oratory work is varied somewhat, and the courses will be entirely separate when the new laboratory is completed. But a number of colleges insist that the entrance requirements in chemistry must be on a par with those in other subjects, and after a student has passed those requirements and entered college his knowledge of the subject must be disregarded and he must elect a beginners' course. The colleges, as a rule, are not to be criticized for this state of affairs because two courses in general chemistry naturally mean a greater teaching force than one and a more complete physical equipment. These are often impossible to obtain.

Now comes up the question of the advisability of such a division, when possible, some of the obstacles, and the assistance the high schools may give to the plan. The statistics of the College Entrance Examination Board show that the percentage of students passing chemistry of late years is slightly below that of all subjects. And we may judge from this (assuming that the students get as good instruction in chemistry as in other subjects, and I believe they do) that the requirements are high enough to insure that a student will have considerable knowledge of the subject when he enters college. As to the part of that knowledge that may be the basis of a more advanced course, I shall speak later.

Let us now suppose that these students are put into a beginners course in general chemistry, and see what happens to them. They may be divided into three groups. First, those who are really interested and desire a further knowledge of the subject. Their work in high school was usually of such a high grade that they are prepared for rapid advancement and expect it. But they begin the course by hearing lectures that are too familiar to them to be very instructive or spectacular and by doing laboratory work that is too near a repetition of former trials to stimulate wonder or ingenuity. The idea of work of any variety is distasteful to some college students, but the repetition of work, once carefully performed, seems little short of criminal. And to be required to assemble a hydrogen generator for the second time and be exposed to the same dangers of an explosion seems much more of a waste of time to these students than if their mathematics course in college should begin with the multiplication table. Is it surprising that many in this group of students lose interest, become discouraged and do mediocre work, and finally forget their inclination toward chemistry?

The second group will include those students who think

their knowledge of chemistry will make a beginners' course a "cinch;" and a third group will be made up of those who go into the course for no special reason other than because it is required, or makes a convenient schedule, or because their parents requested it. To both of these groups the results are often more disastrous than they might have been if they had had no elementary knowledge of the subject. It will require little study for them to do passable work for weeks or possibly a whole term; but before the year is nearly over they will find that they have neglected new ideas and new principles to such an extent that they cannot keep up with the class or pass their final examinations.

In a more general way we may say that any course which requires a widely different amount of mental exertion from two groups of students is defective from the standpoint of mental development and efficiency. And as these considerations outweigh all others in any elementary course, it is evident that such results as I have mentioned are not based on sound pedagogic principles.

There are difficulties to be encountered in accepting high school chemistry or physics as a foundation for a more advanced course in the particular science. A student's fitness to take up the more advanced course can be determined to only a small extent by his ability to pass the college entrance requirements and, paradoxical as it may seem, the schools that do not expect to prepare their students for college usually give them a sounder foundation for college chemistry than preparatory schools whose reputation is based on their ability to get students by the entrance examinations.

Although the college entrance requirements in such subjects as Latin, mathematics, or history may give us a fair estimate of a student's training in those subjects, they produce little evidence on numerous intangible factors that make for his proficiency in chemistry. A school that will look upon chemistry merely as a part of a general education will emphasize *quality* more than *quantity*. It will teach a student to *generalize* rather than *memorize*. And the training and analytical reasoning that may be developed in the laboratory are not sacrificed for cold facts that may later be put on paper. The chemical training that will help a man or woman to solve the problems of later life may, at the same time, meet the requirements of the College Entrance Examination Board or any similar board, and be the best asset toward progress in his college career.

The so-called "requirements" of the Board are too broad to be covered completely by any secondary school (or college) and should rather be considered as a list of suggested topics, or not at all. And teachers sometimes fail to get their students through their entrance examinations because they pay too much attention to these requirements and not enough to thoroughness and the correct methods of making their courses interesting. An attempt to cover the requirements as far as possible often results in a "cramming" process that may be useful in getting students through their examinations, but leaves their knowledge in such a chaotic state that it is unsuited to any further purpose. It is quite possible for them to memorize a mass of facts relating to physical and chemical properties and uses of chemical substances, along with a number of definitions and laws, and squeeze through an entrance examination. They may not be able to write a formula or equation that had not been previously memorized; they may have no idea of nomenclature or the relations between elements or compounds; problems in chemical arithmetic may have been lightly passed over; and they may be barely acquainted with a chemical laboratory. Yet I can conceive of such students passing the entrance requirements in chemistry and believing that their knowledge should entitle them to an advanced course in general chemistry.

But the number of such exceptional cases is decreasing rapidly, and it does not take long to weed them out and drop them into their proper atmosphere. Better laboratories and equipment and higher standards among high schools are having their effect on the quality of work turned out.

Of course the most striking evidences of poor training are still to be found in a student's laboratory work, and this is the most difficult consideration to meet in giving credit to high school chemistry. This is due not only to the lack of laboratory facilities but to the fact that laboratory instruction for beginners is the most tiresome of the teaching of chemistry and is most likely to be neglected. This instruction is punctuated ("punctured" would be as good a word) by such daily happenings as illustrating the correct method of removing a stopper from a bottle, explaining that a rat-tail file really looks like a rat's tail and is not triangular, that hot glass should not be cooled under the tap, that the hydrochloric acid is within reach and not to be found on the sideshelf, and that the "bottle of glowing splints" has ceased glowing. In addition we may be

called upon for police duty such as locating lost apparatus, putting out fires, and caring for the injured.

On such a day as this it will require a bit of self-control not to see imaginary precipitates and not to accept an apparatus merely because it "works."

Another thing that affects the laboratory training in some schools is the limited periods for such work and the desire to cover a set number of exercises. This sometimes forces a teacher to accept results that would be repeated if a student could find a period to do so and not fall behind the rest of the class. And if a student is hurrying through an exercise which should be finished before a bell concludes the exercise, he will usually miss the conclusion that should be drawn and gain little from the experiment. Also such things as poor cork boring and glass working are likely to be overlooked.

I saw a good example of this attempt to save time only a few days ago. I intended giving some extra work to a student who was unusually well prepared in textbook chemistry, and asked him whether he had had any experience with balances. He replied that his school had balances of different kinds but they were not required to use them, and were allowed to take their chemicals to the druggist to be weighed. That they saved time by so doing is doubtful, and if accuracy was the reason for such a procedure, a scientist was evidently wasted in a corner drug store. And the boy would have been better prepared for the work I assigned him if he had used only crude laboratory scales and had learned to replace weights.

It is a difficult matter to get much information on a student's laboratory training by an inspection of his laboratory notebook. Frequently the poorest students will be able to prepare the best looking books, and important conclusions and original work will be concealed with copied lists of apparatus and materials or lengthy instructions for performing the experiments. And I have seen books containing long lists of chemical formulas and their names which the students were supposed to memorize.

A large part of this memory work can be eliminated by a greater emphasis on the rules of nomenclature and valence. These are topics that will add little to a student's general knowledge but they will help clear up the confusion that results from this new language of chemistry. Previous study of grammar and languages has taught him that different endings are used merely to give different shades of meaning to words, and it is

hard for him to grasp the idea that such compounds as sulphides, sulphites, and sulphates can be quite different substances. Nomenclature is usually not explained until a systematic study of acids, bases, and salts has been made, but I believe that the main ideas may be combined with valence earlier in the course. If you explain that there is a relation between the name and radical of a salt and the name and radical of some acid the writing of formulas and naming of compounds will at once assume a logical basis. The topic may be taught in an interesting way that will result in a spirit of rivalry in the class and the dread of meeting unfamiliar chemical substances will disappear. And the variety need not be limited to the compounds that have been studied in detail. One of the questions on the Board paper last June asked for the *name* of the *potassium salt* of *chlorplatinic acid* and the *name* of the compound that *magnesium* forms with *silicon*. The answers frequently included the statement that they had never used or studied the substances.

Another cause of a one-sided knowledge of chemistry is occasionally met in students who have had a detailed drill on some comparatively unimportant topic. This is usually in the teacher's own special field of interest, and a thing that he is most competent to teach. A student's notebook sometimes shows the influence of an organic chemist in the large number of organic equations and processes, of an industrial chemist in the emphasis that is put upon such things as soaps, dyes, explosives, etc. I even remember one student who could write practically no chemical formulas, and yet he had studied osmotic pressure until he attempted to apply it to all doubtful points, and another who considered alloys the most important subject in elementary chemistry. Any teacher of chemistry must have some particular hobby to keep alive his interest in the science, but this can be persistently inflicted on an entire class of beginners only at the sacrifice of more fundamental topics. But there are sure to be some bright students in the class who can be assigned outside reading or special laboratory work in some particular field and the results will be very encouraging to them and to the teacher.

Apart from these more or less exceptional deficiencies noticed in the chemical training of some students is the universal difficulty with chemical arithmetic which we must all face. It is a new application of arithmetic that requires constant repetition

and individual instruction before a student can recognize that it is not a new branch of mathematics. And, after a student has gotten to the point where he can apply mathematical reasoning to chemical problems, we are never sure that his arithmetic will enable him to carry out operations involving such simple things as decimal fractions, percentages, or proportions.

Summing up these and other defects in a student's knowledge of chemistry is an easy matter. As often as not they are due to his dislike of the subject or a mental inability to grasp the ideas of a science that demands clear reasoning and careful observation. And there is no remedy that any high school or college can use to correct this. But the outlook for chemistry is brighter than ever before, and it is becoming more and more popular over the country. This popularity is due, to some extent, to the remarkable advertisement given to chemical products and chemists at the outbreak of the war. Fathers, formerly unfamiliar with college curricula, are reading of chemistry in their daily papers and advising their sons to take it throughout their college course. Aside from any possible effect on our advanced courses, this popularity will certainly have its influence on elementary chemistry in high schools and colleges; it will gradually result in a readjustment of courses, the addition of new equipment, and the raising of standards. And it is to be hoped that more colleges will be in a position to give credit to high school chemistry and that the quality of work done by the high schools will continue to improve.

EXTENSION AGRICULTURAL WORK EXPANDED.

Full development of the plans for further wartime expansion of the extension service of the United States Department of Agriculture will mean at least one demonstration agent—possibly two, a man and a woman—in nearly every agricultural county in the nation and a woman in each of the large cities to give advice on production, conservation, and utilization of food products. This is a statement in the annual report of the Secretary of Agriculture, David F. Houston.

Through provisions in the food production act for development of the extension service more than 1,600 emergency demonstration agents had been appointed by the end of October, making a total of approximately 5,000 cooperative extension workers. Nearly 750 additional counties are cooperating with the department under the food production act in employing county agents. Men county agents total now about 2,000, many district agents are supervising their activities, and about 1,300 women home demonstration agents are at work. These agents not only are performing the normal and emergency demonstration and educational work but also are assisting in other special Governmental activities, such as the Liberty Loan and food conservation campaigns.

A UNIT COURSE IN ECONOMIC GEOGRAPHY FOR THE HIGH SCHOOL.[1]

By J. PAUL GOODE,
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Three events loom large in the history of geography in America in the past century. One was the arrival in America seventy-two years ago of the Swiss geographer, Arnold Henry Guyot, who brought with him the wide horizon of the real geographer, the kindly human interest which is the geographer's greatest asset, and an inspiration for scientific analysis, hunting out the fundamental physical influences at work on life, and conditioning life at every turn.

A second event of great significance was the appointment in the early nineties of a committee of the N. E. A. consisting of Davis, King and Collie, who reported out the argument for the new American study of physiography.

The third event of moment was the publication in England, in 1889, of a volume on Commercial Geography by George G. Chisholm.

The work of Guyot gave scientific organization to geography. We had our science expressing itself in the formal divisions, mathematical, physical and political. And then the fascinating development of physical geography began, the livest and most broadening subject taught in the schools a generation ago.

Then came the specialists in geology, and transformed physical geography, a subject which had been throbbing with life interest, into a narrow, lifeless geometry of three dimensions, applied to land forms—a chapter in geology, and to a large extent renegade to geography.

Chisholm, however, chose an angle of the horizon packed with human interest, and strove, as Guyot had done, to find the fundamental physical factors, the geographic influences, at work in the broad field of commerce. And we in America borrowed his work bodily. He had made an octavo volume of about 700 pages, filled with detail. He dealt with the geographic influences at work; then he discussed all the important commodities of commerce; then he presented a study of all the commercial countries. Within two years Cyrus C. Adams brought out the first American text in commercial geography, and in a smaller format, in 500 pages, he went over the same ground as Chisholm, giving us conditions, commodities and countries—omitting nothing.

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[1]Read at the Annual Meeting of the Central Association of Science and Mathematics Teachers, Columbus, Ohio, Dec. 1, 1917.

This text of Adams was a godsend. It gave an opportunity for a host of earnest teachers to bring into the curriculum a subject with limitless possibilities of interest, applying the scientific method in the interpretation of everyday matters of industry and trade. Not that the text *gave* this interpretation. It gave masses of fact, and the teacher and student brought to bear whatever genius they may have had in making geographic interpretations. But the very mass of fact implied in 500 pages treating all commodities and all lands has proved a great handicap. Condensing all this material into so small a space, and rushing over it in a unit course, has of necessity reduced the work of the student to so rapid a scanning of many things as to leave small chance of getting fundamentals firmly planted in memory, or to achieve any particular ease of mind in the thinking out of causal relations. The success of the Adams text and the recognized value of this phase of geography as an element in education have produced in this country a string of texts: Redway, 1903; Trotter, 1903; MacFarlane, 1905; Gannett, Garrison, and Houston, 1905; Gregory, Keller and Bishop, 1910; Robinson, 1910; Brigham, 1911; J. Russell Smith, 1914; McFarlane, J. (University of Manchester), 1914 (?); Dryer, 1916; J. Russell Smith, 1917.

These texts all show a strong family resemblance. To the latest one of them the Chisholm features are plainly still with us. But the variations in emphasis, one from another, show a recognition of the difficulties we are discussing. MacFarlane (1905) gave himself some freedom in discussing certain crops and other commodities of vegetable origin, making that part of his composition less dry, less like a catalog of things. That was because he was first a botanist, and brought to his composition a mind full of the lore of plants, and with a lively interest in plant life. Keller and Bishop (1910) gave rein to the discussion of the human element, doing their part of their three-cornered text most suggestively. Robinson (1910) and Brigham (1911) began to amplify the discussion of certain crops, and other topics. While J. Russell Smith permitted himself pages enough to get quite away from the dry as dust textbook composition and make a discussion which is interesting reading even for the man in the street. But this freedom made a book too large and expensive for the audience he wished to serve, and the condensed version (1917) has with it still the great handicap of too large a field.

After many years of teaching in this special field of geography, and striving always to delimit the scope of the subject so that one may, by earnest effort, in the course of a lifetime acquire something akin to an "easy mind" in the subject, I have come to a positive conviction that our error has always been one of uncurbed ambition. We have been greedy in trying to do the whole world of things at once. We have been like the boy in the fable who reached into the jar and took so many nuts he could not remove his hand. In the slang of the countryside, "we have bit off more than we could chaw."

Why not then face the difficulty boldly. Let us limit our scope to a field we can cover. Let us establish standards in subject matter and methods of presentation. Let us be brave enough to undertake only what can be covered thoroughly, with time enough to fix in the mind of the student the principles of geographic interpretation. If it shall turn out that more time in the curriculum must be given to geography, let us not worry; let us go to it, and demand the place in the curriculum the subject requires.

I would have in every high school at least three unit courses in geography: I. The Elements of Geography. II. Economic Geography. III. Commercial Countries.

In every junior high school the first of these courses, I. "The Elements of Geography," should be given. This course should give a general view of the physical factors at work upon mankind. This may well be a ground work upon which all later courses in geography and history may be based. It should be required of every student.

The second of the courses mentioned above, "Economic Geography," is the one of largest present interest, and is the part of the geographic horizon to which I wish to invite most careful attention at this time. Its proper place is in the senior high school. In economic geography I would discuss two groups of topics: A. The Commodities of Commerce. B. The Geography of Trade. This calls for a recognition of the entire list of geographic influences, acting as they may act, anywhere in the world, in the production and movement of a given commodity. This establishes a wide view of world relations, and gives a good preparation for the study, in the following course, of a country or a region, as an industrial, or commercial, or national unity. Let us set down here a more detailed outline of this important course:

II. Economic Geography.
- A. The Chief Commodities of Commerce:
  1. The products of the forest:
     Lumber, rubber and other gums, naval stores, cork, drugs, etc.
  2. Products of hunting and fishing.
  3. The products of the grazing lands:
     Wool, hides, meats.
  4. Products of the farm, orchard, and garden:
     The cereals: wheat, corn, rice, rye, oats, barley, etc.
     Sugar cane, sugar beet, potatoes and other root crops.
     Fruits of tropic and temperate lands.
     Vegetables, and varied crops.
     Dairy products, hides, wool, meat.
  5. Products of mines, quarries, wells:
     The mineral fuels: coal, petroleum, gas.
     The metals: iron, copper, lead, zinc, mercury.
     The precious metals: gold, silver, platinum, etc.
     Building stones, cement, precious stones.
     Clay products.
  6. Products of factories:
     Foods and beverages.
     Textiles, leather goods, clothing.
     Paper and other manufactures of wood.
     Machinery and metal wares.
     Chemical manufactures.
- B. The Geography of Trade.
  1. Advantage of position with reference to trade, e. g.:
     Advantage of Western Europe, opposite Eastern America, and close by.
     Advantage of Europe in trade with Africa and India.
     Advantage of United States in Western South America, and the Orient, etc.
  2. Development of great land routes of trade:
     The great highways of Europe and Asia, of North America, etc.
  3. The great ocean routes:
     The highway of the North Atlantic, of the Mediterranean, of the Orient, of Panama, and the Great Circle Routes.
  4. The organization of ocean commerce:
     Tramp and liner.
     Shipping trusts, government participation.
  5. The development of market centers:
     Great general, and transshipment points.
     Markets of special commodities:
       Wheat and cotton at Liverpool.
       Wool, tea, diamonds, at London.
       Coffee at New York.
       Bananas at New Orleans, etc.

The scope outlined above is amply big for a unit course. There is no subject in the curriculum which offers a better opportunity than this course does, for training the logical faculty, or for widening the horizon of the student in matters of everyday interest in the world about him. It is a liberal education in itself.

As an illustration of the method of study, showing the thought-provoking possibilities of the subject, let us indicate the subtopics in the study of one of the cereals, say:

Wheat:

1. Plant characters of wheat, and our knowledge of its origin.
2. Climate and soil required.
3. Types and qualities of wheat as related to climate and soil.
4. World's wheat producing areas, and reasons for location and importance.
5. Influence in production, of surface, labor conditions, use of machinery, transportation facilities, skill of the farmer.
6. Problems of milling, marketing, establishment of the world market center, and the method of making the price.
7. Wheat in international commerce and politics.
8. The problem of the wheat supply of the future.

In every stage of this discussion the teacher is on guard that the *geographic influences* are being discussed. The criterion of any point discussed must be as to whether it is, or has, a geographic influence. This discussion of wheat goes down to the roots of things for many influences at work in Britain and Germany, and in the United States of America and other newer, wheat producing lands. It calls for some knowledge of historical development in all the lands in the world whose people must buy wheat, or who have wheat to sell.

Or suppose we take the topic sugar, we should have:

Sugar:

1. Historical sketch of the rise of sugar.
2. Plant characters of cane.
3. Climate and soil required for cane.
4. World's producing areas, as related to climate, soil, labor, transportation and market facilities.
5. A survey of the farmer's problems—planting, cultivation, harvesting, preparation, marketing.
6. Historical sketch of the rise of the beet.
7. Changes in character of plant under domestication.
8. Soil and climate required.
9. Beet areas in Europe and America.
10. Rise of the beet in America.
11. Sugar refining, and marketing the final product; location of refineries.
12. Uses of sugar: their influence on commerce.
13. Output of sugar by the important producing regions.
14. Government interest in the sugar industry in Europe and America.
15. The future of the sugar supply.

Here again one must open the question of tropical versus temperate agriculture and labor conditions. Must look into the almost unbelievable complications, economic and geographic, following a settled government policy in Germany of fostering the production of beet sugar. Political relations between Britain and Germany, and between Britain and her colonies—as well as unsuspected economic influences in our American attitude toward "Imperialism."

Or suppose the topic is the most important metal, iron, we must inquire as to:

Iron:

1. The qualities which make iron and steel valuable.
2. The significance of iron in the civilization of the race.
3. Chief iron producing regions of the world.
4. Methods of winning the ore: in Minnesota, in Sweden, in Spain, etc.
5. Problems in transportation of the ore—the question of limestone and coke.
6. The phosphorus question, and steel making processes.
7. Present rank of regions producing iron and steel: a geographic interpretation of their relative importance.
8. The price of steel since 1850, and the significance in industry and trade of cheap steel.
9. The trust control and the development of government interest in steel manufacture.
10. Estimates of the world's total stock of ore and the significance of the location of the ore bodies.

It may be observed that the study is avowedly economic, as well as geographic, and geographic and economic influences underlying industry, commerce and human welfare are sought in every stage of the study. This makes of the subject a fascinating field for both teacher and student, and it has the superlative advantage of continual growth, of eternal youth. It is quite unlike a paradigm, or a table of constants, calling for memory only. It calls for an alert mind, a mind that takes delight in searching out the causes which explain the intensely interesting and endlessly moving phenomena of the world about us.

Let us now mention the logical successor to the course in economic geography, a course which makes a somewhat careful geographic interpretation of the commerce of some of the leading commercial countries. Let's call it

III. Commercial Countries—a course which should come as late as possible in the senior high school.

The point of view is now avowedly regional. The unit is the country. And again we run the gamut of physical influences, acting now in a given region, and getting certain responses in industry, transportation, and the segregation and occupations of the people. Now all we have learned of the influences at work in the location and development of commodities may be used as material for clear thinking in the present status and stage of industrial development of a country. We shall find here an interest in a *people* and their place in the world.

There should be no attempt to discuss all countries. Important countries should be chosen and studied as to commercial development and possibilities.

We may begin with a statement of the rapid growth of world trade in recent decades, and take for our task the geographic interpretation of this marvelous development.

We shall want to know what leading countries have been most conspicuously active in this development, and in what particular lines of development, industrial and commercial, these nations have been conspicuous. We shall look for the trend of commerce in the leading commodities exported and imported through the decades, and be able to account for the changes in the rank of these commodities; for the dying out of some lines and the rise of new lines to a prominent position.

Then we must analyze the trade to show the international relations, the trend of trade through the decades with the countries of largest intercourse—and be able to find in the facts we deal with the reasons for these changes.

First of all the countries studied, should be our own. And we should compare it with some young tropical country, say Brazil. Then Britain, an old nation, might be studied in similar fashion and compared with the United States of America as a young nation, and with India as an old tropical nation. Germany in turn may be taken up and studied in contrast to Russia, and possibly with Argentina, to bring out the surprising contrasts. France and Australia, for contrasts of old and young, and with Japan and China for another phase of development of old countries, presenting phenomenal signs of rejuvenescence.

The opportunities for development in such a course are endless. It is a course as live and as recent as the evening paper. Though the principles of the subject may be rooted in the very nature of things, its data are in continual flux with the everyday changes in the weather, the changes of market conditions, and the continual shifting of international political relations.

For these reasons it is not an easy study to prepare in or to teach. The materials are all around us in every business we may look into. There is a continual incentive to follow developments in such periodicals as the *World's Work*, *The Nation's Business*, and the more technical trade magazines. Especially fortunate are we in our government, which in special monographs in many fields is publishing, at no cost to us, the finest material obtainable. The daily *Commerce Reports* are invaluable. The special reports of consuls and trade experts put the richest storehouses of material into our hands. Even the daily papers have grist for our mill, and just in proportion as we are properly educated the space devoted to scandal and gossip in the press will decrease.

No course has such a wealth of potential graphic material

waiting for it. Graphic statistics become eloquent. Maps of every sort have tremendous possibilities in presenting our subject matter. An atlas should be in every student's hand. Unfortunately, there is no atlas in existence that really meets our needs.

No subject could be more significantly aided by pictures. These three courses could with profit use a thousand typical pictures. As photographs, as lantern slides, best of all as stereographs, they may be made strongly to reinforce the text or class discussion. Even the "movies" occasionally, as it were by accident, give us valuable educational films. I fondly hope the time may come when such courses may be equipped with moving picture machines and libraries of films.

This entire subject, properly presented, is not merely three unit courses or three years of high school work. It is rather an inoculation of intellectual good health which will last through life. The reward of such a study is found in the exhilaration of a constantly widening horizon, and of a migration out of a provincial frame of mind into an atmosphere of serious, worthy cosmopolitan interests.

LABORATORY EFFICIENCY.

By H. R. Smith,

Lake View High School, Chicago.

In no occupation is there more need to heed the war-time exhortations of "prevent waste and lost motion" than in that of teaching. Of all teachers, the science teachers are likely to feel that they are the most efficient. Yet, laboratory methods may be as formal and "dead" as any others.

Laboratories are equipped with the idea of giving students real experience. Yet in many cases chemistry teaching at present is nothing more for the students than mental excursions radiating from the class textbook, rather than mental excursions from real basic facts. Few teachers outline a practical course in chemistry for their students. Chemistry is generally taken as it comes from a book rather than as it comes in life.

If laboratory work is to bring the results desired, namely: training in observation and reasoning, and stimulation of interest, it must be *initiated* in the laboratory. Perhaps the laboratory work does go better if the textbook is studied first. But the main reason for this is that most students will gladly

allow the textbook to do their thinking for them, while they perform only the mechanical operations of handling the materials and copying notes from the book. It does not seem wise to offer training to our students that will do no more than make them compete with labor-saving machinery for a job.

Preparation for laboratory work should be that which will reveal the purpose of the experiment, and at the same time afford such a grasp of conditions and procedure as to make the experiment a mental as well as a physical exercise. If results and explanations are known previous to the performance of the experiment, then it becomes a waste of time and materials. If this plan is used it will easily be possible to find certain members in every class who record results *not as they actually happened* but as they were said to happen in the textbook. Such work is mere sham, and demoralizing to the student. The proper function of our textbooks in chemistry, as they are now constituted, is to correct and amplify student deductions from experimental facts, and supply information not readily available by experiment.

With the belief that laboratory work was not furnishing the desired results, the instructors of chemistry in the Lake View and Nicholas Senn Schools, Chicago, combined efforts over four years ago to improve it. Their results have been obtained by trial and elimination of methods in classes totalling over a thousand students to date. Their joint findings are herewith presented for the cause of better chemistry teaching. The positively good results they have obtained are not conditioned by local or variable factors but rest upon broad general principles that may be applied by any teacher who wills to do so.

Regarding the textbook as an improper source of preparation for laboratory work, introductions of about one printed page for each experiment were prepared. They contain points of historical and general interest, examples which typify the "scientific method of study," a working mental start on the chemical action involved, and the specific purpose of the experiment. The introduction and experiment sheets are given out to students the day previous to the laboratory work. Each student is required to present evidence of preparation by exhibiting a written statement of the purpose of the experiment on the sheet of it to be used as a record before the student is permitted to perform the work.

Since the loose sheets permit final binding of the direction

sheet with the record sheet, no attempt is made to record the procedure of the experiment. Each student records results only in final form as the work is performed, having section numbers corresponding to those on the direction sheet. Students that are addicted to the "copy" habit are inclined to demur at this requirement, but after a thorough trial they prefer the new way. The direction sheets contain questions which involve the use of the recorded experimental data. They serve to emphasize the main points of the experiment.

At the close of the laboratory period all record sheets are deposited with the instructor. The student retains the printed sheets and studies them, using the text in preparation for the next recitation day. At this time the record sheets are returned after a cursory inspection by the instructor. During recitation the records are corrected by students, preferably with pencil or ink of different color, and presented to the instructor for final approval and credit. The students are given to understand that they will be discredited for *not correcting mistakes* rather than making them.

A sample experiment with student record may be found on the following pages.

Discoveries.

In all manufacturing operations there are waste products which are likely to be discarded with little attention because of their seeming worthlessness. Soap makers formerly allowed tons of glycerin to flow from the boiling tanks into the sewer because they did not know its value. Instead of paying thousands of dollars annually for the removal of its garbage, a certain eastern city receives a bonus of $600 per day from a company of thrifty men who collect the garbage and extract products of value from it. A chemist in a government mint had a suspicion that valuable metals were allowed to escape in the process of refining silver and gold. He began an investigation and found that thousands of dollars' worth of platinum was going to waste every month.

In 1826, while Balard was studying the composition of the waste liquor after crystallizing the salt out of the water from salt marshes, he obtained a dark brown liquid having an unpleasant odor. He called it "muride" because of its source, but later changed it to "bromin" because of its bad odor. By this study of a waste product a new element was discovered for the use of men. An opportunity to discover the element, bromin, was offered to Justus von Liebig. Some years before Balard's discovery a salt company sent him a jar of liquid containing much bromin, and requested him to examine it. After a casual study of it he believed it to be iodin chlorid. After Balard's discovery Liebig saw the mistake which he had made by relying on preconceived ideas and not on experimental facts. He placed the jar in a special cabinet for storing mistakes—"l'armoire des fautes," as he called it. Balard became famous by his discovery of the element, bromin. His inferences and conclusions were based on facts that he had obtained directly from nature by experiment. He used what is called the scientific method.

Near Stassfurt, Germany, much "Abraumsalz" (refuse salts) were thrown aside in the process of mining rock salt. Two chemists, Rose and Rammelsberg, made a study of it and found that it contained much potassium and magnesium. Today these mines are worked for the salts

of these metals and the sodium chlorid has become the by-product. The "Stassfurt Salts" constitute one of Germany's richest natural resources. The world's chief supply of bromin and potassium are obtained from these salts.

BROMIN.

Experiment.

Purpose.—State it on the separate sheet used for record.
Apparatus.—15 cm. test tubes with a one-hole cork stopper to fit; L tube; stirring rod.
Materials.—Concentrated sulfuric acid, potassium bromid, powdered manganese dioxid, carbon disulfid, starch.

I. **Preparation:**

Bore a hole through a cork that has been fitted to a 15 cm. tube and insert the short arm of the L tube in the hole. Mix several medium sized crystals, or 1 cc. powdered crystals, with twice its bulk of powdered manganese dioxid and put it in the 15 cm. tube. Adjust the clamp to hold the tube in a slanting position and fill another tube two-thirds full of cold water. Pour 2 cc. of concentrated sulfuric acid into 1 cc. of water and cool it. Then pour it upon the dry mixture in the other tube, insert the cork with L tube, and hold the tube of cold water so that the long arm of the L tube will dip **just below** the surface of the water. Heat the mixture **slowly** and **constantly** with a medium flame until the reddish vapor is driven beyond the bend in the L tube. Do not heat enough to boil the black liquid through the L tube nor stop heating until all the red vapor is driven over. Then stop heating and remove the tube of water **at once.** The dark liquid in the bottom of the tube is bromin. Describe the action in the generator during the preparation. (?) Diagram the apparatus and label the parts. Write the equation and balance it. The molecule of bromin has two atoms.

$$?KBr + MnO_2 + ?H_2SO_4 \rightarrow KHSO_4 + MnSO_4 + ? + ?$$

II. **Properties:**

(a) The colored water above the bromin in the tube is called "bromin water." Pour 2 cc. of it into a 10 cm. tube, add 1 cc. (no more) of carbon disulfid, cover the tube with thumb and shake it. Most of the disulfid settles to the bottom. Compare the colors of disulfid and water, which show the relative solubilities of bromin in the two liquids. (?)

(b) Wet a stirring rod and roll it in dry powdered starch. Heat a drop or two of bromin liquid and hold the rod with starch in the vapor of bromin. (?) This effect is used as a test for bromin.

(c) Test bromin water with both colors of litmus. (?) Pour some on a little cochineal solution. (?) Note the effect of the bromin on the cork used in the generator. (?) Pour any liquid bromin remaining after tests into the stock bottle of bromin water.

(d) Tabulate the physical and chemical properties of bromin. Give the degree of solubility.

BROMIN.

Experiment 35, Dorothy Borg.

Purpose.—To prepare and study the properties of bromin.

I. **Preparation:**

$$2KBr + MnO_2 + 3H_2SO_4 \rightarrow 2KHSO_4 + MnSO_4 + 2H_2O + Br_2$$

The substance in the generator has a very dark brown color which, when heated, turns a reddish brown. The heat applied forces the reddish vapor through the L tube into the water forming bromin water. Bromin settles in the bottom of the tube.

II. **Properties:**

a. The disulfid is colored much more than the water.
b. Bromin colors starch brown.
c. Bromin water colors litmus paper red and bleaches it.
d.

Physical	Chemical
1. Color—dark red liquid.	1. Bromin turns starch a brown color.
2. Odor—very sharp and disagreeable.	2. Bromin water is an acid because it turns blue litmus paper red.

3. Sp. gr.—heavier than water.
4. Solubility—less in water than in carbon disulfid.

3. It bleaches calico but does not act as vigorously as chlorin.
4. It attacks cork.

The methods mentioned give satisfactory results on the following points:

1. The introduction to experiments gives a working knowledge of the problems involved in the experiment.

2. Training in accurate observation is secured by making the permanent record in the laboratory *at the time the results are obtained.*

3. The thinking out and writing of record is done at the time and in the place in which the student can have individual instruction from the teacher.

4. The loose leaf experiment sheets placed with the student's record sheets makes a suitable permanent record without any copying of procedure by the student.

5. The loose leaf plan saves time and paper for the student.

6. The loose leaf plan eliminates the drudgery of handling piles of student note books.

7. The loose leaf plan permits collection of student records each day without taking away the assignment for the following day.

8. The loose leaf plan permits carrying student records easily anywhere to be read and graded during the teacher's unoccupied time.

9. The loose leaf plan permits insertion of practical experiments of local interest.

10. Students correct their own mistakes under the supervision of teacher during the following recitation period.

11. The removal of the temptation to unfair practices in doing work promotes general honesty.

12. The study of chemistry is more comprehensible when experiments are grouped under larger heads.

13. The knowledge in the results is developed by the questions to be answered by the student.

14. Library and extra work is systematically developed as optional work.

Price of Preprints of the "Status of Mathematics in Secondary Schools."

Preprints of this article, published in the January, February, March and April issues, may be had for 10 cents from Mr. M. J. Newell, High School, Evanston, Ill., or from Mr. Alfred Davis, William and Mary College, Williamsburg, Va.

THE REORGANIZATION OF HIGH SCHOOL SCIENCE.

FRED D. BARBER,
Illinois State Normal University, Normal, Ill.

The day has passed when it was pertinent to ask whether high school science needs reorganization; high school science is now being reorganized. While this reorganization has been taking place some of our scientific friends have been so engrossed in the daily routine of teaching science that they have had no time to glance over their spectacles and note the condition towards which high school science is rapidly drifting. Other of our scientific friends, more alert, have seen with unwilling eyes the drift of science but they have held firmly to the traditions of their own high school and college days; they have rebelled against every innovation; they have contended that the charge that much of our high school science teaching is a near failure from the point of view of the boy or girl is heretical and should be suppressed; they have compared those educators who asked that high school science be reorganized to the boy who cried "Wolf" when there was no wolf; they have said: "Leave high school science alone; we admit that the drift is bad at the present, but the organization and subject matter is the best possible; college and university men approve of it; apparent defects are due to poor teaching and we are about to remedy that defect."

This *laissez faire* attitude has been most pronounced in teachers of the biological and earth sciences; teachers of physical science have, as a rule, taken more kindly to the demand that high school science be modified, that it be adapted to the interests of high school pupils and to the needs of modern life.

Generally speaking, physical geography, physiology, zoology and botany have been the sciences taught in the first two years of the high school course. The *laissez faire* attitude of the teachers of these subjects, coupled with the growing conviction that the reorganization of high school science must begin at the bottom of the high school science curriculum, is now leading rapidly to the elimination of these subjects from the high school curriculum and the substitution of other subjects which are believed by many to be better adapted to the needs and interests of the pupils in the early years of the high school. The extent to which these four science subjects have declined during the past fifteen years—especially during the past five years—will be seen by a study of the accompanying graphs and Table I.

TABLE I.

Table showing per cent increase (bold face) or decrease (light face) during the five years from 1910 to 1915 in the *percentage enrollment* in the high school science subjects.

Subject	United States	Iowa	Wisconsin	Illinois	Ohio
Physics	3%	4%	**17%**	4%	10%
Chemistry	**7%**	**15%**	**4%**	**3%**	**8%**
Physical Geography	25%	35%	33%	24%	18%
Physiology	38%	31%	30%	8%	44%
Botany	45%	39%	30%	17%	28%
Zoology	59%	54%	50%	22%	49%
Agriculture	**54%**	**513%**	**24%**	**52%**	**231%**
Domestic Economy	**241%**	**593%**	**237%**	**65%**	**340%**

From these data it appears that physics is now nearly holding its own, that chemistry is making slight gains, that physical geography, physiology, botany and zoology are all rapidly losing ground and will soon disappear as high school subjects, or at least they will soon become unimportant subjects in the high school curriculum. It also appears that agriculture and domestic economy are everywhere making rapid gains. It is unfortunate that the reports of the Commissioner of Education, from which these figures are taken, do not show the part which general science is taking in this realignment of high school science.[1]

It is interesting to note the approximate date at which we may expect physical geography, physiology, botany and zoology to disappear, or practically disappear, from the high school curriculum if their decline continues at the rate indicated from 1910 to 1915.

TABLE II.

Table showing approximate date at which the science subjects generally taught during the first two years of the high school curriculum may be expected practically to disappear, their places being taken by other subjects.

Subject	United States	Iowa	Wisconsin	Illinois	Ohio
Physical Geography	1930	1924	1925	1931	1937
Physiology	1923	1926	1927	1965	1920
Botany	1921	1923	1927	1939	1928
Zoology	1919	1919	1920	1933	1921

It would probably be erroneous to conclude, however, that high school science as a whole is at the present time declining

[1]The High School Supervisor of West Virginia in his report for 1915-1916 gives the total enrollment in high school science subjects in that state as follows: Physics, 831; Chemistry, 992; Botany, 738; Agriculture, 1431; Biology, 2194; and General Science, 1133.

A report of the Committee on Science in the High School of Tomorrow, given before the Central Association of Science and Mathematics Teachers, at Columbus, Ohio, November 30, 1917, shows in thirty-six large high schools in the Upper Mississippi Valley, having a total enrollment of 42,107 students, the following percentage enrollment in the sciences: Chemistry, 10.5 %; Physics, 10%; Botany, 4.9%; Zoology, 2.3%; General Science, 7.1%; Physiography, 5.4%; Physiology, 2.5%.

if we include as high school science agriculture, domestic economy, general science and general biology. A study of the reports of the Commissioner of Education for the past twenty years, incomplete though the reports are, leads to the conclusion that the total percentage enrollment in high school science subjects did decline from about 1900 to 1910 but from 1910 to 1915 there was a slight increase.

An analysis of the nature and significance of these shifts in our high school science curriculum is important. It seems fair to presume that, in a large measure, physical geography and physiology have given place to general science as the first-year-science course. Likewise, it is apparent that botany and zoology have given place to general biology in many schools in certain states and to agriculture in many schools in many states. Domestic economy, without doubt, has displaced the older sciences in many cases.

Why were these shifts made? Was it mere caprice, a desire on the part of teacher or pupil, or both, to try something new or different? Or is there a deep-lying conviction held by superintendents, principals, science teachers, and educators in general that the science courses which have been generally offered during the first two years of the high school curriculum are not well adapted to that purpose?

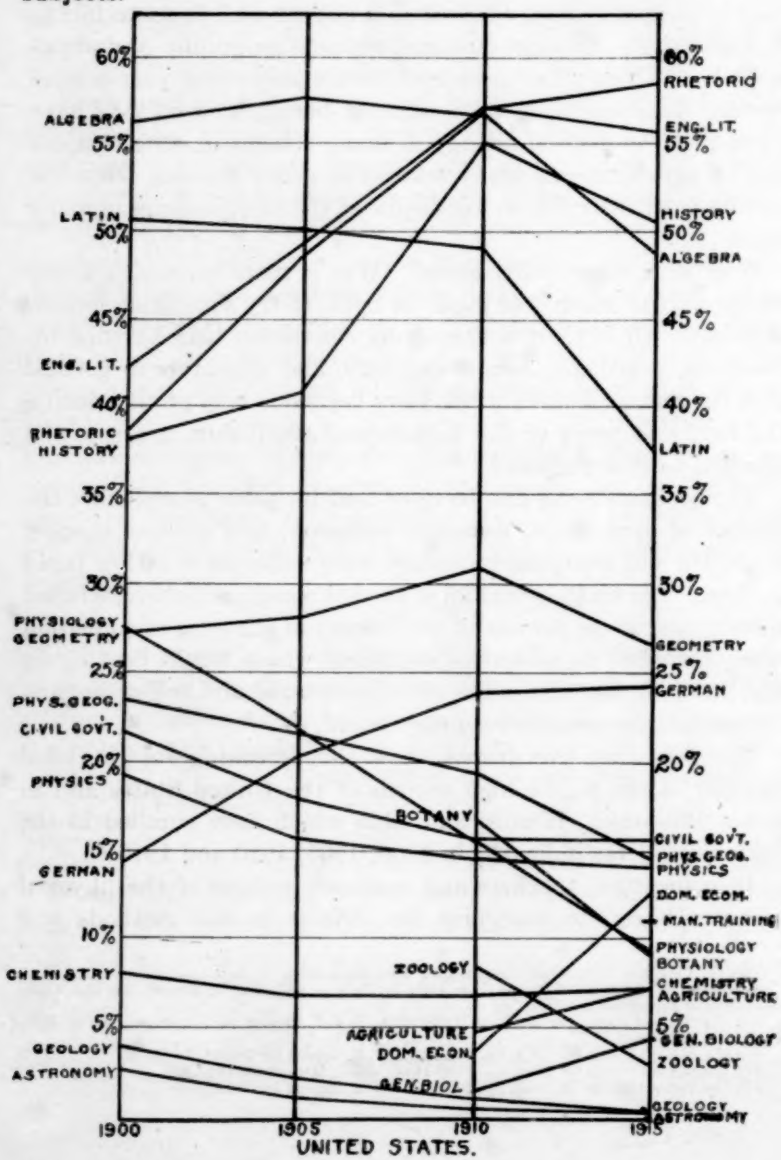
The accompanying graphs show that for some years before the advent of agriculture, domestic economy, and general science, all of the old recognized sciences were suffering a rather rapid decline. The truth is that all of the old recognized sciences failed some years ago to command the respect of students of education when regarded as educative materials which would best equip the pupil to take his place as a prosperous and self-respecting citizen in this twentieth-century world.

The following five graphs show the percentage of the total number of the public high schools of the United States and in Iowa, Wisconsin, Illinois, and Ohio which were enrolled in the various subjects indicated in 1900, 1905, 1910 and 1915.[2]

In a measure, teachers and textbook writers of the physical sciences began to recognize the defects in the methods and

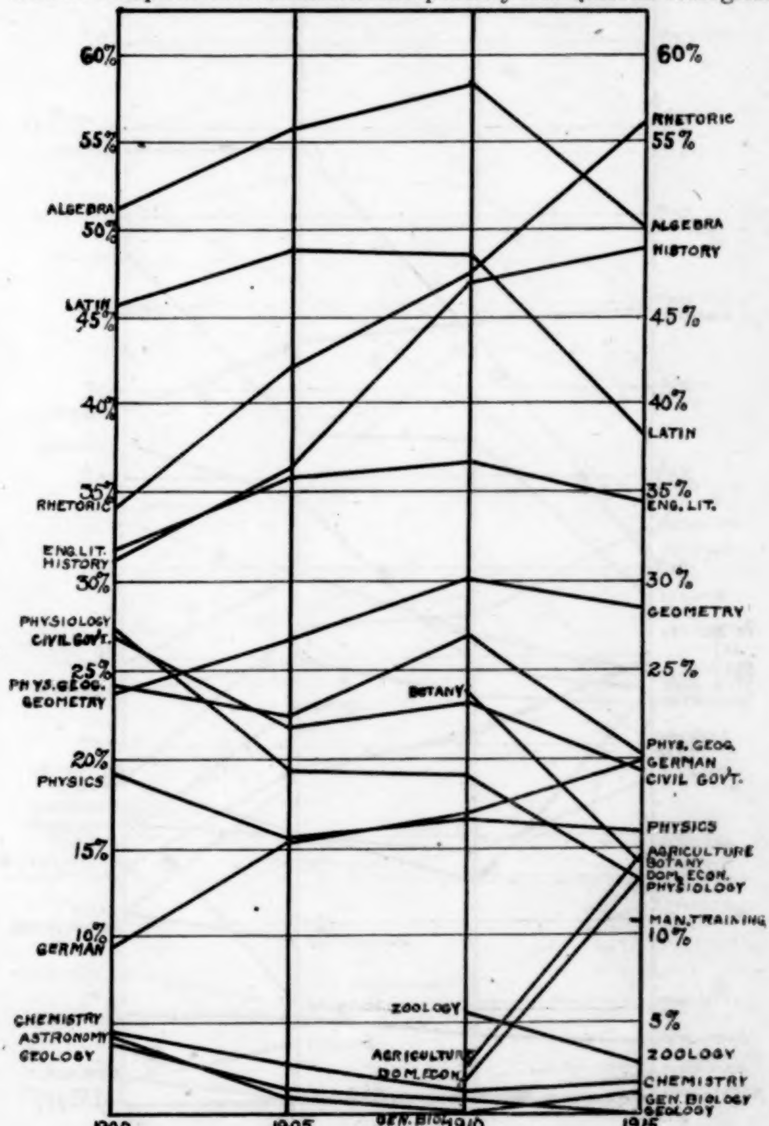
[2]Note: The data from which these graphs were made are to be found as follows:
Summary for the United States from 1890 to 1915, p. 487, Vol. 2, Report of the Commissioner of Education for 1916.
For the various states for 1900, pp. 2138-2139, Vol. 2, Report of Commissioner of Education for 1899-1900.
For the various states for 1905, pp. 832-833, Vol. 2, Report for 1905.
For the various states for 1910, pp. 1182-1184, Vol. 2, Report for 1910.
For the various states for 1915, pp. 500-503, Vol. 2, Report for 1916.

materials of high school physics and chemistry some years ago. Some of the recent textbooks and considerable of the teaching bear evidence of a conscientious effort to make these courses more practical, more worth while and more interesting to the pupil. While there is unlimited room for further improvement, yet the changes already effected have been partly responsible for the check in the decline in percentage enrollment in these subjects.



UNITED STATES.

In rather marked contrast with the attitude of the more progressive teachers of the physical sciences is the *laissez faire* attitude of many of the most influential leaders among the teachers of the biological sciences. One has but to study the addresses given at the educational meetings of the past fifteen years, to read the articles contributed to our educational journals, and to compare the resolutions adopted by the various biological



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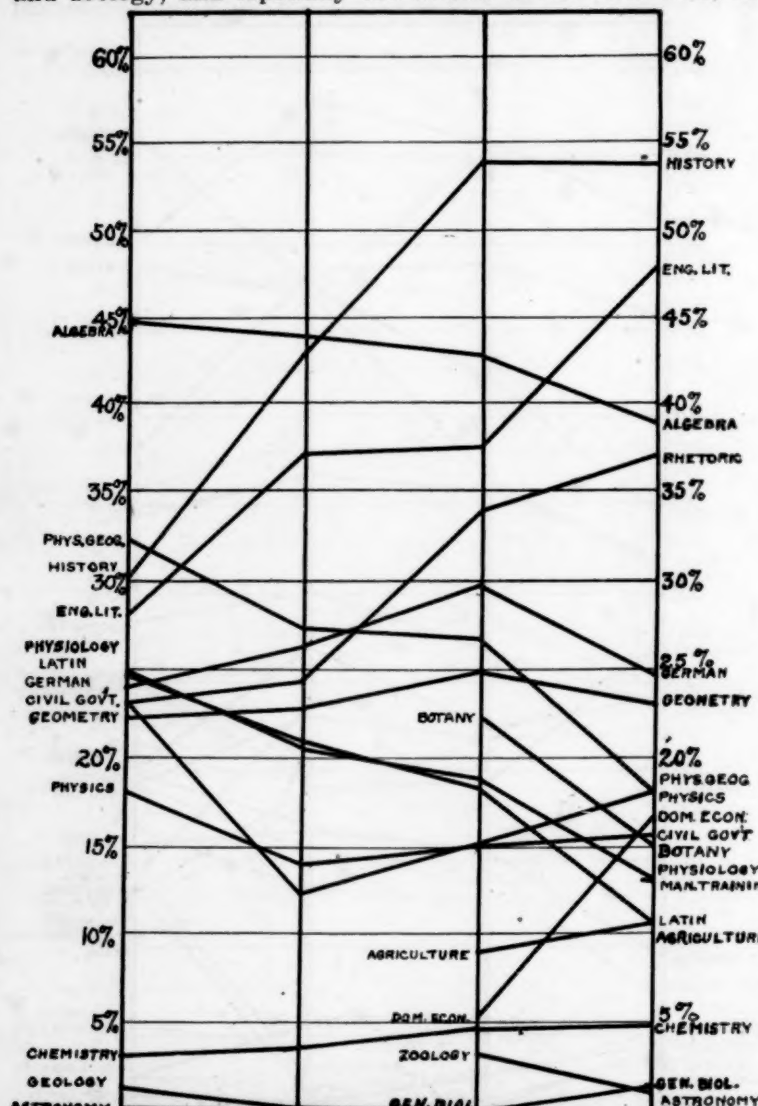
and physical science sections of our educational associations to note clearly this different attitude. There is little doubt that the attitude taken by the teachers of those sciences usually given in the first two years of the high school has been, in a large measure, responsible for the changes now taking place.

If the teachers of physical geography, physiology, botany and zoology, and especially the writers of the texts used, had



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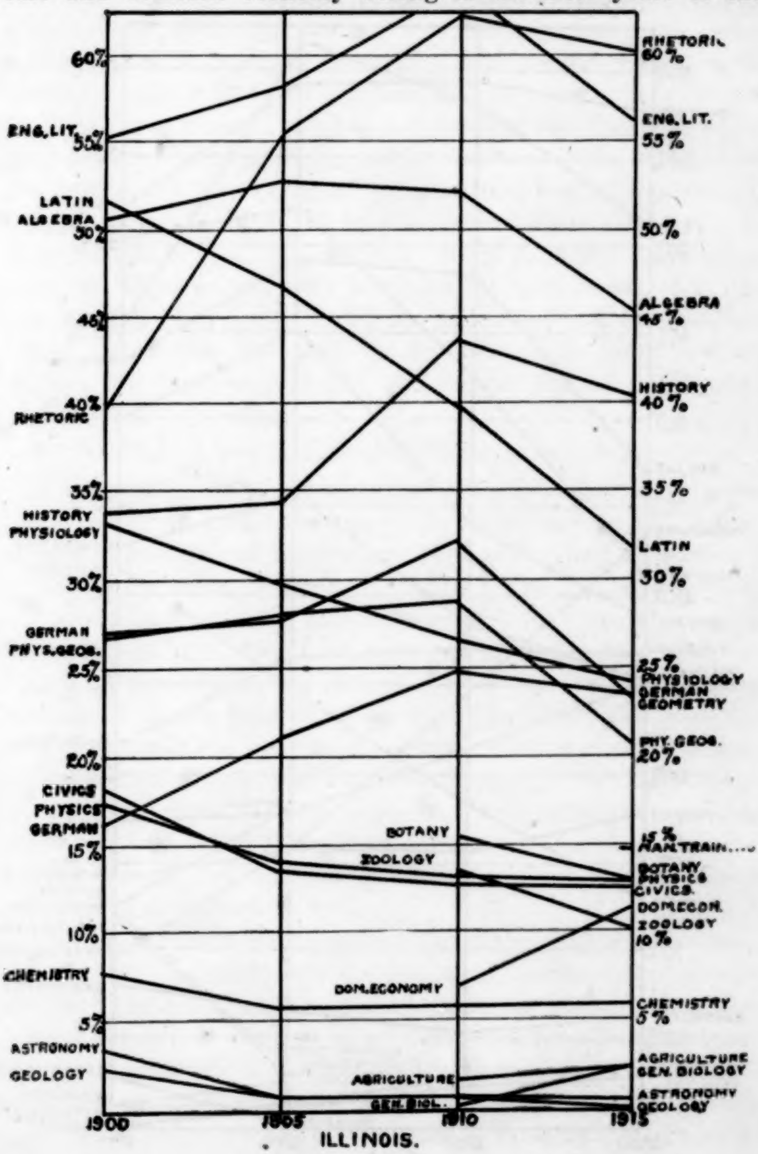
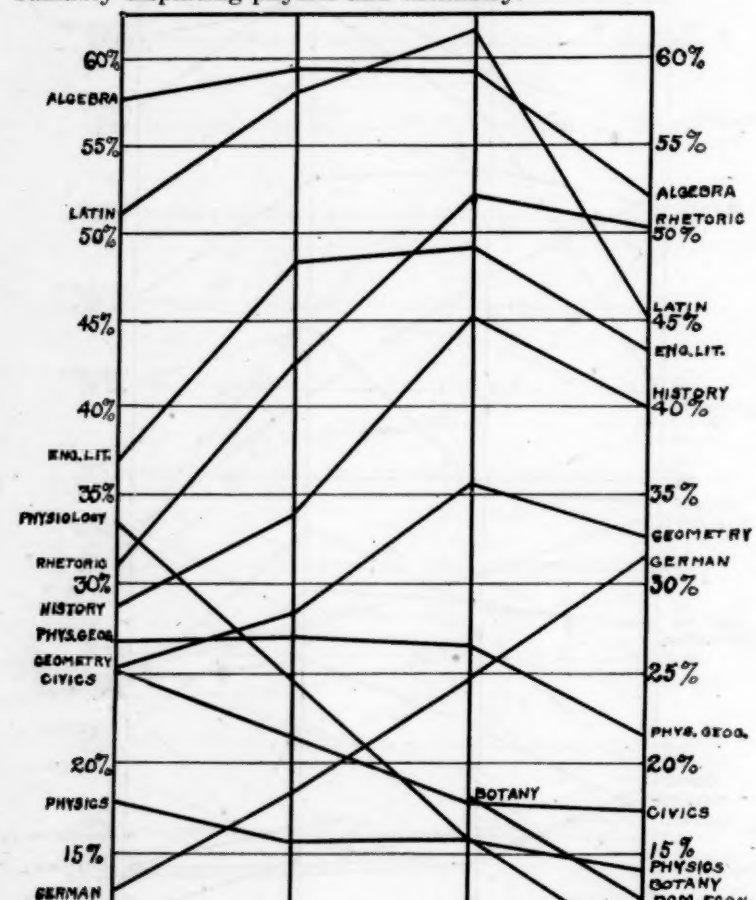
found a way of so modifying those courses some years ago as to make them appeal to the pupils as being more worth while and appeal to superintendents and principals as being of higher educational value, it is doubtful if general science, agriculture and domestic economy would ever have made much progress in displacing them. Many courses offered in agriculture and domestic economy belong in the later years of the



ILLINOIS.

high school curriculum; such courses presuppose a knowledge of certain principles of science. Had the courses offered in the first two years really afforded the proper foundation for the study of agriculture and domestic economy, I am convinced that in our better school systems these two new "applied sciences" would have been placed farther up in the course, presumably displacing physics and chemistry.



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A Condition, not a Theory.

Our scientific friends who have been given to jeering at agriculture, domestic economy and general science as being "near science" and the "offspring of soft pedagogy" are now face to face with a condition, not a theory. Whether we classify these new subjects as science subjects or not, the fact remains that they have come to stay. With the departure of physical geography, physiology, botany and zoology from the curriculum of the high school these new subjects will receive more attention and will be better taught. If these new subjects, as they are at present taught, lack some of the elements which gave to the older subjects greater educational value, it behooves the devotees of "pure science" to bend their best efforts towards helping so to shape up future high school science courses that those elements may be preserved. It is no secret that many students of education who have looked with favor upon the introduction of agriculture and domestic economy into the high school curriculum feel that the *substitution* of these courses, as they are frequently taught, for the old line science courses is a doubtful proceeding.

Nature of the Readjusted High School Science.

In the readjustment of high school science we should endeavor to preserve the best elements to be found in the old regime of special science and incorporate them with the best elements of the new regime of applied science. The old courses were not altogether bad; the new courses are not altogether good. Reorganized high school science should incorporate the elements of worthwhileness and interest from the new courses with some of the breadth of view and much of the scholarly attainment claimed for the old courses. If a course of science instruction extending from the seventh or eighth grade through the twelfth grade can be so organized and so taught as to attain these ends—and there is no apparent reason why this can not be done—then the reorganization of high school science will have been well worth while.

There can be but little question about the older sciences having afforded an insight into the historical significance of science and into the traditional man-made units of human knowledge concerning nature which the applied sciences will never give. It may be debatable whether the older sciences necessarily afforded a better opportunity for mental training, a claim insisted upon by the adherents of "pure science." Possibly it is inevitable

that a newly organized subject shall lack, to a considerable degree, the conciseness and exactness which characterizes a subject which has been decades if not centuries in developing. It is this element of conciseness and exactness so manifest in the dead languages and in mathematics which gave those subjects for many years the reputation of being of the greatest educational value. Moreover, the teaching of such a static subject largely becomes a matter of imitation. The body of subject matter to be covered is well defined; the method of instruction is largely predetermined; the beginning teacher can do fairly well if he but follow closely in the footsteps of his own teacher. No such slavish imitation will produce acceptable results when applied to a developing, dynamic subject such as agriculture, domestic economy or general science. These subjects are in their formative stage and will remain so for many years to come.

A Danger to be Avoided.

The disrepute into which agriculture and domestic economy have fallen in the eyes of scientists lies in the fact that in a multitude of cases these subjects have assumed chiefly the form of arts, not sciences. To substitute the art of agriculture or the art of cooking for a training in the fundamental principles of science is an educational error which can produce nothing less than a failure quite as serious as the failure of "pure science" in which the principles of science were taught abstracted from all settings of human welfare. The present tendencies to substitute courses in agriculture and domestic economy for all science courses hitherto offered in the first two years of the high school course can result in nothing short of revolt on the part of every educator who appreciates the fact that all progress along material lines rests finally upon a knowledge of the fundamental principles of science. The pendulum in swinging from "pure science" to the art of agriculture or the art of domestic economy has swung far past its normal position and is bound to return.

The proper reorganization of high school science consists in the establishment of a required stem course of science which shall incorporate the elements of historical significance and scholarship from the old regime with the elements of true worth and interest from the new regime. This course should be two years in length; it must deal with materials of universal value; it must present science in its psychological and pedago-

gical order, not the logical order of special science; it must recognize the natural interests and the point of view of the pupil, not the interests and point of view of the trained scientist; it must afford the necessary foundation for an understanding of the principles involved in the art of agriculture and the art of domestic economy and at the same time it must provide the foundation for the further study of science in the college and university.

The "Ordinary" Four-Year High School.

The "ordinary" four-year high school is impossible of definition. Sometimes there are but two or three teachers; sometimes there are twenty-five or fifty teachers; some of these schools are strictly rural in character; some of them are strictly urban in character. While it is highly desirable that all high schools shall be standardized to the largest possible extent, we must allow rather wide margins in the science courses offered and the sequence in which those courses are taken. It is possible, however, to standardize the science curriculum so far as a *two-year stem course* is involved. The two-year stem course here advocated should be equally applicable to high schools of every type, the two-year high school, the three-year high school, the four-year high school, the rural high school and the urban high school. It will be equally applicable to every type of high school because it must deal with materials of universal interest and importance. The materials dealt with and the fundamental principles taught must be those which have universal application.

Character of the Two-Year Stem Course.

If this stem course in science is to meet the needs of all beginning students: it must meet the needs of the 95 per cent who never expect to go to college; it must meet the needs of the 5 per cent who do expect to go to college; it must meet the needs of the ever increasing percentage who will study agriculture as a preparation for life's work; it must meet the needs of the still more rapidly increasing percentage who will study domestic economy as a preparation for life's work; it must deal with materials which appeal to all high school pupils as being of such vital importance that an abiding interest in the study of science results; it must develop and make clear a large body of scientific principles which should constitute a portion of the equipment of every well educated citizen—the scientific pabulum of an independently thinking people.

It must not be the end and aim of this stem course to make artisans in agriculture or in domestic economy of all our young people. It must give every pupil a glimpse of the history of the development of science and of scientific achievement at least from colonial days to the present time. They must see something of the influence of science upon the march of civilization. While the practical phases of science as it affects our lives here and now must be prominent in this two-year required course, it must also contain some of the cultural elements to be obtained from a survey of the historic past. Agriculture and domestic economy as they are now generally taught are as impossible of survival as the science to be taught in this stem course as were the old line sciences which are now passing out of the curriculum.

It matters little under what name or title this two-year course is listed; it is of imperative importance that it shall develop the foundation principles of science and do so in such a manner as to enlist the interest of the pupil and lead him into the habit of ever seeking the scientific explanation of common life-experiences. I know of no name or title more appropriate for such a course than to call it a *two-year course in general science.*

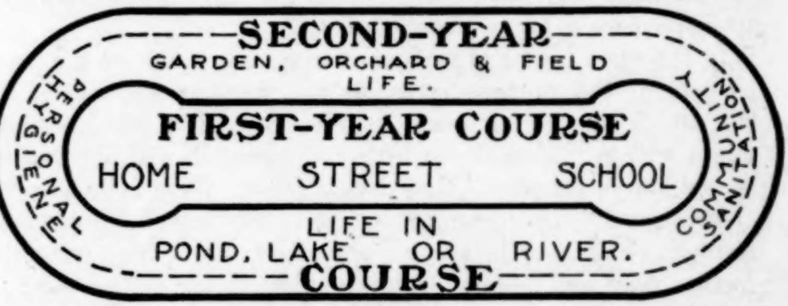
No matter under what name this two-year course is listed, its organization must be that of general science and not that of special science. It will be general science because it will disregard the artificial boundaries of special science; it will be general science because its units of instruction will be the natural, Creator-made units and not the artificial, man-made units of special science; it will have the general science organization because the principles taught will arise out of a study of the pupil's environment and not out of a study of types, many of which are entirely foreign to the pupil's present or future environment, as is the case with special science.

As a general plan for organizing the material of one's environment into a two-year course I suggest that a study of the home, the school and the street leading from the home to the school be made the first year; a study of an outer field comprising the animal and plant life found in the garden, in the orchard and in the field, together with such a study of aquatic life as may be available shall comprise the second year's work.

Suggested Two-Year Required Course in General Science.

Naturally, physical science materials, such as lighting and heating systems, refrigeration, water supply and sewage disposal, the use of labor-saving machines, the weather, climate,

ventilation, together with food and nutrition and microorganisms will comprise the course, and personal and community welfare will be the point of attack. The second course will reach out on every side for materials and will include a study of the plant and animal life found in the outlying environment of the school and community. It should also include a more comprehensive study of personal hygiene and community sanitation. The second year's course will, therefore, deal chiefly with biological materials although the influence of physical environment will everywhere be an important consideration.



Much of the material which it is proposed to use in this two-year stem course is material which might properly be also studied in applied courses in agriculture and domestic economy. The manner of treatment, however, would be quite different from that given either in the old special science courses or in the newer applied science courses where the same material might be studied. For example, suppose that we consider the corn plant as the unite of instruction. In the special science, botany, no such unit of instruction would be tolerated. If corn were mentioned, it would first be mentioned, perhaps, when studying the unit *germination;* next, it might be mentioned many pages later when the unit *roots* was under consideration; its next mention might be under *stems;* thirty or forty pages later it might be mentioned under the unit *leaves;* later it might be mentioned under *flowers;* finally, it might again be mentioned under the unit *fruits and seeds.* Thus the study of this most important cultivated plant (which every pupil should study as a natural unit) is actually fragmentary and disjointed simply because special science refuses to recognize natural, Creator-made units but insists in serving up science in artificial, man-made units.

In agriculture, however, the corn plant and its environment *is* a logical unit because agriculture does deal with the

natural or Creator-made units. But in applied agriculture the question raised is: How can we so select seed, how prepare the seed bed and cultivate the crop that we can secure more bushels of corn from an acre of land? The study of corn thus becomes more or less a study of the art of corn raising. Of course, the matter of insect pests will necessarily arise and so the study of corn will introduce some study of zoology, as will also the study of the preparation of the seed bed and the cultivation of the corn introduce some study of soil physics and weather and climate. Agriculture is necessarily general science and not special science so far as it is science at all.

In this stem course of general science with which we are now concerned, the purpose is somewhat different and therefore the attack and development is different. Here the question might well be: How does corn serve mankind, and how has it served him in the past? How does it grow? What is its natural environment? The technical and detailed study of producing it more cheaply or in greater abundance or of improving its quality may well be left for development in the course in agriculture; only those phases should be presented in this required course in general science which have to do with an understanding of corn, its nature, its natural environment, its cultivation and its uses—those phases which should be the possession of every well-educated citizen. That the prevailing methods of cultivation may be improved and that the corn plant is subject to climatic conditions, to diseases and to insect pests should be matters of common knowledge but the detailed discussion of these points should never be made the chief characteristics of a study of corn in a science course required of all high school pupils.

If we turn to the materials treated in domestic economy we find a similar situation. Everybody should know certain truths concerning foods and nutrition but we may safely leave to the class in domestic science the study of the art of cooking foods and much of the science involved in their preparation. Everybody is interested in food values and in the comparative costs of foods but we are willing that the detailed study of food values and balanced rations shall be taught in the domestic science class as well as the art of setting the table, arranging the knives, forks and spoons and a multitude of other details.

It seems perfectly clear to me that there is a great body of science material dealing with the environment of all high school students which has practically uniform significance in their lives. This material, therefore, is of equal value to all high

school students; it is also nearly equally accessible to them. The basic course in high school science must deal with this body of science materials found in the environment of the pupils and it must develop out of a study of this material the principles of science which have universal significance.

Advantages of a Generally Adopted Basic Course.

From an administrative point of view it is clearly advisable that all high schools adopt a uniform science curriculum so far as it is possible to do so without sacrificing the interests and welfare of the pupils. Such a plan, if generally adopted, would enable the pupils to do two years of science study in the two-year or the three-year high school and then complete the course in a four-year high school without loss. It would lessen expense and confusion in the large four-year high school by eliminating the need of differentiated science courses in the first two years. If such a course were required of all pupils in the first two years of the high school it would eliminate confusion and loss of time sometimes occasioned by pupils changing from one prescribed course to another within the same high school. Finally, I believe that colleges and universities could more easily adapt their entrance requirements and the first courses they offer to such a uniform preparation than they can to the extremely varied preparation which applicants for admission now offer.

Elective Science Courses.

The two-year required basic course in science must not be the only science course offered. In every rural high school courses in agriculture should be offered; in practically all high schools courses in domestic economy should be offered. Inasmuch, however, as the basic course will deal largely with materials which are closely related to the materials utilized in agriculture and domestic economy courses, these special courses may be shortened materially. Most high schools will also offer courses in special science, such as physical geography, physiology, general biology, physics and chemistry. The extent to which these elective courses can be offered will be determined by the facilities of the school.

Even the special science courses in the high school of tomorrow must undergo readjustment. Probably they will still have the special science organization, i. e., the units of instruction will be the artificial, man-made units and the principles will be developed through the study of the most pronounced types;

still it is inevitable, I believe, that they will treat less of the theoretical aspects of science and more of the practical aspects. After having studied the practical aspects of science for two years in the general science course, pupils will *demand* that their later science courses have a much stronger bearing upon the practical, upon the here and now, than has been the case with any of our special science courses in the past. Many years of experience have taught me that pupils who have been trained in the study of applied science are rarely if ever satisfied unless the relation of the scientific principle to human welfare is made prominent.

Science in the Coming Junior High School.

Slowly but surely the 6-3-3 plan of organization of the public school is gaining ground. Eventually the junior high school will become an important reality. When that time comes we may hope to see science taught with success in the seventh and eighth grades. Properly trained teachers and properly equipped laboratories will be available. The seventh year may then well be devoted to nature study during the fall and spring months and to physiology and hygiene during the winter months. The first year's work of the proposed two-year course in general science can be done in the eighth year and the second year's work can be done in the ninth year. This will leave three years to be devoted to courses in agriculture, domestic economy or special science courses as they may be elected.

To High School Science Teachers.

Is it not worth while for high school science teachers, principals and superintendents to use every influence towards introducing some uniformity into our high school science curriculum? Is it not time that science teachers and high school principals should awaken to a realization of the chaotic condition into which high school science has been plunged? Are science teachers and principals willing that high school pupils shall be deprived of all science training during the first two years of the course except such as they may secure from the ordinary courses in agriculture and domestic economy?

I believe that this is an opportune time for all teachers who are interested in high school science and who appreciate its value as a vital factor in education to get together, forget their allegiance to some pet field of science, and unite upon some common plan for the placing of high school science in its rightful place as an important factor in universal education.

GLACIAL MORAINES IN THE VICINITY OF ESTES PARK, COLORADO.

By Lyman C. Wooster,
State Normal School, Emporia, Kansas.

While spending his August vacation near Estes Park village, the writer unexpectedly penetrated a region of enormous glacial activity of prehistoric times. Having given years to the study of the moraines of Kansas, Wisconsin, Michigan, Illinois, Indiana and Ohio belonging to the great continental glacier that once covered the northern United States from Dakota to Cape Cod, the writer became at once interested in these moraines of the alpine glaciers of the Rocky Mountains that formerly filled the upper valleys of the Thompson River and its tributaries.

The introduction to the moraines came when a party of relatives and friends laid a picnic luncheon in the Thompson River at the gateway to Moraine Park. Giant boulders filled the river, so we were safe from a wetting. The river here falls in cascades one hundred feet through and over the terminal moraine of a glacier that formerly filled Moraine Park. This glacier undoubtedly received tributary ice rivers down Forest, Spruce and Fern Canyons and was in its time a glacier of no mean dimensions. It pushed but two or three miles beyond the mouths of the canyons, for it encountered a great glacier from the southwest and the two stopped in the narrow gap between Eagle Cliff and Giant-track Mountains and here left their front moraines. Later, when the Moraine Park glacier melted back to and up the canyons, the front and lateral moraines impounded the water from the melting ice and thus produced a lake two or three miles in length and nearly one mile in width. Gradually this lake became filled with silt from the mountains and the moraines, slowly the outlet of the lake lowered its channel through the front moraine till in the course of time the green of dry land replaced the blue of the water and Moraine Park was formed.

Students of Rocky Mountain history will be interested in a boulder which lies at the gateway to the park which shows that the present mountains were formed where ancient mountains had yielded to the pounding of the waves of an old-time ocean. This boulder consists of rounded pebbles of granite, mica schist and beach sand all fused into a compact rock when the present mountains were crushed and folded and made into a mighty range during the Tertiary period.

On the north side of Moraine Park lies a moderately developed lateral moraine, but on the south side is the remarkable ridge of boulders from which the park takes its name. At its middle part this moraine rises five hundred feet above the park floor on the north and four hundred feet above the valley of Mill Creek on the south. From this middle point the moraine slopes endwise to the eastward till it dies down a short distance beyond the terminal moraine on the Thompson River. From its remarkable development and its straight course this moraine must have been formed between two glaciers and is therefore an interglacial moraine comparable with the interlobate moraines of the continental glacier of Wisconsin and eastward. It would be strange if there were not a ridge of gneiss in the axis of this moraine but no rock in place was observed.

Still further south, between Mill Creek and Glacier Creek, is another moraine of similar character but of more massive proportions. Its crest is a thousand feet higher than the crest of its companion interglacial moraine to the north and it rises six hundred fifty feet above the valley of Glacier Creek on the south. This interglacial moraine heads near Flat-top Mountain and Halletts Peak and extends in a northeasterly direction nearly to the Y. M. C. A. conference grounds. It must have been formed from glaciers that flowed down Mill Creek valley on the north and a powerful group of ice rivers on the south which flowed out of Glacier Gorge, Loch Vale and the Tyndall Glacier Valley. The southern slope of the moraine is very abrupt and can be climbed by horses only by following a zigzag trail. The northern slope is more moderate and is heavily forested with pine, especially in the vicinity of Bierstadt Lake and Bear Lake.

Other moraines undoubtedly border the valleys in this heavily glaciated region north of the Longs Peak group of mountains but more time than the writer had at his disposal would be necessary to enable one to make a detailed description of them.

Four miles up Fall River from Estes Park village, a short distance beyond the Fish Hatchery, is the best developed terminal moraine seen in the vicinity of Estes Park. Fall River tumbles in a series of cascades over the successive ridges of this moraine down a total distance of five hundred feet. In general appearance, these morainic ridges greatly resemble similar ridges in the bluffs south of Whitewater, Wisconsin, belonging to the moraine of the Wisconsin glacier.

Beyond the terminal moraine of Fall River valley the melting glacier left a lake four miles long and half a mile wide. This in time became filled with sediment and is now Horseshoe Park. On either side of the park are weak lateral moraines.

Perhaps the most unique glacial phenomena are shown in the valley of Roaring River, a small stream which joins Fall River from the north near the head of Horseshoe Park. The glacier which plowed its way down Fall River valley carried a heavy body of ice which cleaned out the valley from mountain to mountain on either side and cut very deep, so deep that Roaring River was left with its mouth two hundred feet above the level of the main stream and is compelled to reach it down a series of waterfalls. Above these falls the river descends two thousand feet in five miles, so, rapids and waterfalls characterize the stream nearly to its source. The glacier that plowed out the valley of this river must have been comparatively weak, for even with its high gradient it did not cut as deeply as the one which filled Fall River valley. The weakness of the glacier is still further shown by the number of recessional moraines between the mouth and the source of the stream. The ice river flowed to its junction with the main glacier for unknown thousands of years in what the geologist terms a hanging valley, then as warmer years succeeded colder years it repeatedly melted back longer distances and advanced shorter distances till it retreated to its mountain source in the ridge connecting Mount Fairchild and Hagues Peak and ceased to exist as an ice river. The final retreat of this glacier may be seen today in a cirque, at the base of the ridge, scoured smooth by the ice.

Just in front of the last recessional moraine of this glacier, at a level five hundred feet below its summit, is Lawn Lake, and back of the moraine in hollows in the rock are two or three small bodies of water termed lakes. Snowdrifts lie here and there but with no indication of flowage except in one drift high up on the sides of Mount Fairchild. This has the ribbed appearance later seen on the surface of Halletts Glacier.

Part of the ice that pushed beyond Lawn Lake may have crossed over into Black Canyon through a low place in the divide now occupied in part by small lakes. This will account for the weakness of Roaring River glacier in the lower part of its course. At about the place of division of Roaring River glacier the right or western arm of this ice river encountered

a low mountain, divided, passing around the mountain and united below it. This mountain was thus a nunatak in a field of ice. Most of the water flows at present on the eastern side, but a small lake was seen in the western valley.

Halletts Glacier was the last objective in this August vacation. Our party, consisting of a nephew, two daughters, a minister and the writer climbed the ridge connecting Hagues Peak with Mummy Mountain from the cirque of Roaring River glacier up a slope covered so thickly with disintegration boulders that the solid rock of the ridge was nowhere visible; and thence we descended four or five hundred feet to Halletts Glacier. The ridge has an elevation of thirteen thousand four hundred feet above sea level and gave a fine view of the glacier lying in its cirque below with its terminal moraine immediately below it. On descending to the moraine we found that it consisted of great, angular boulders forming a terminal moraine in front of the ice, rising, like so many others in the Estes Park region, five hundred feet above the creek erosion valley below.

Apparently Halletts Glacier has never left the cirque which it has excavated on the east side of the ridge extending north from Hagues Peak but has continuously shoved out disintegration boulders which it has plucked from the ridge behind it and has thus backed into the ridge. Sometime it will back through where gaps are already visible and the glacier will cease to exist.

On crossing the ridge connecting Mummy Mountain with Hagues Peak, the first view of Halletts Glacier was very fine, almost awe-inspiring. The glacier was glistening white from newly fallen snow and seen from a height of five hundred feet in its setting of black rock on all sides, one felt like sitting down and studying it as he would an oil painting.

Halletts Glacier is properly a névé, and, while it is still alive and has a crevasse where the névé drops from a higher to a lower level, the glacier has done little work beyond excavating its cirque and pushing out its great terminal moraine of blocks of gneiss.

The winter preceding our visit had been very stormy and the cirque was unusually full of snow at the time of our visit in August, so we had no opportunity to visit the crevasse and get a view of the interior of the névé. The concave surface of the névé is evenly ribbed from back to front. No attempt was made to find the cause of the ribbing but no other bodies

of snow had the ribbed surface except one high up on Mount Fairchild and it was therefore surmised that the ridges were produced by the motion of the glacier.

The mountains of the Estes Park region consist chiefly of gneiss and mica schist. Even the so-called Pillars of Hercules in Thompson Canyon are but the edges of layers of fine textured mica schist. The boulders of all the moraines have not been moved more than fifteen miles, most of them not more than five or six. They are therefore still angular like the disintegration boulders of Hagues Peak and have not been smoothed by sliding. It may be of interest to the mineralogist to learn that many of the boulders on the slopes of the ridge connecting Hagues Peak and Mummy Mountain contain twin crystals of feldspar.

Several vacations would be required for a complete study of all these morainic ridges in the vicinity of Estes Park, but such studies would take one into a region replete with gorges, snow fields and rugged mountain peaks and would fill the hearts of the fisherman, mountain climber, teacher of physical geography, geologist and artist with the deepest pleasure.

CAROLINA TIN DEPOSITS.

The United States Geological Survey, Department of the Interior, has recently issued a report on the tin resources of the Kings Mountain District, North Carolina and South Carolina. The presence of cassiterite, oxide of tin, at many places in the district has led to much prospecting and to attempts at mining. In at least one place—the Ross mine, near Gaffney—placer mining was temporarily profitable. Practically all the work on the lodes, which are pegmatite dikes carrying cassiterite, has been done at a loss but the results of this work have not been sufficiently conclusive to prove or disprove the value of some of the deposits. The report can be had free on application to the Director, U. S. Geological Survey, Washington, D. C., asking for Bulletin 660-D.

THE WAY TO PEACE.

"Any body of free men that compounds with the present German Government is compounding for its own destruction. . . . Any man in America or anywhere else that supposes that the free industry and enterprise of the world can continue if the Pan-German plan is achieved and German power fastened upon the world is as fatuous as the dreamers in Russia. What I am opposed to is not the feeling of the pacifists but their stupidity. . . .

"If we are true friends of freedom of our own or anybody else's we will see that the power of this country and the productivity of this country are raised to their absolute maximum, and that absolutely nobody is allowed to stand in the way of it.

"Our duty is to stand together night and day until the work is finished."
—[From President Wilson's Address to the American Federation of Labor.

PROBLEM DEPARTMENT.

Conducted by J. O. Hassler.

Crane Technical High School and Junior College, Chicago.

This department aims to provide problems of varying degrees of difficulty which will interest anyone engaged in the study of mathematics. Besides those that are interesting per se, *some are practical, some are useful to teachers in class work, and there are occasionally some whose solutions introduce modern mathematical theories and, we hope, encourage further investigation in these directions.*

We desire also to help those who have problems they cannot solve. *Such problems should be so indicated when sent to the Editor, and they will receive immediate attention. Remember, however, that it takes several months for a problem to go through this department to a published solution.*

All readers are invited to propose problems and solve problems here proposed. Problems and solutions will be credited to their authors. Each solution, or proposed problem, sent to the Editor should have the author's name introducing the problem or solution *as on the following pages. In selecting problems for solution we consider* accuracy, completeness, *and* brevity *as essential.*

The Editor of this department desires to serve its readers by making it interesting and helpful to them. If you have any suggestion to make, mail it to the Editor. *Address all communications to J. O. Hassler, 2301 W. 110th Place, Chicago.*

Correction (*Problem* 527).

The following communication from *Prof. B. F. Yanney, Wooster, Ohio,* explains itself. The Editor confesses to the mistake, practically the same as pointed out by him in the issue of June, 1917, under the discussion of Problem 511.

> "Permit me also to call attention to what I believe to be an erroneous statement in your solution of Problem 527. You develop your formula for n on the theory of remainders after monthly payments of \$50 have been made. Now the presumption is, and your result clearly shows, that there is not an exact number of these monthly payments of \$50. Evidently, after the 101st payment there is still a residual, not zero. So that your explanation leading up to the formula is hardly the correct one. The formula, however, is all right. One way of explaining is to let n equal the time during which the compound amount of the unpaid balance of \$4,000 at the nominal rate of 6% (also the effective rate here) becomes equal to the final value of the \$50 monthly payment (annuity) at the effective rate in this case of $(1.06)^{1/12}-1$, and so on."

Fallacy.

541. *Proposed by the Editor.* (See December, 1917, number. Problem 529 is restated below.)

Find the error in the published solution of 529. A correct solution would also be acceptable.

I. *Solution by B. F. Yanney, College of Wooster, Wooster, Ohio.*

The error in question is in the statement,

"$\angle$P equals 1/2 half circle HER less arc HK," which is tacitly assuming that diameter HP of circle S is tangent to circle T.

The theorem is essentially that of Exercise 615 in the 1882 edition of Todhunter's *Elements of Euclid,* and its proof depends upon Exercise 614 of the same book, which latter says:

"The opposite sides of a quadrilateral inscribed in a circle when produced meet at P and Q. Show that the square on PQ is equal to the sum of the squares on the tangents from P and Q to the circle."

We may then prove 529 as follows:

Let O be the center and r the radius of the given circle S. Let C be

the center and R the radius of the circle described on PQ as diameter. Let t_1 and t_2 be the tangents from P and Q, respectively, to circle S.

Now, as is well known, $\overline{OP}^2+\overline{OQ}^2 = 2\overline{OC}^2+2R^2$.

But $\overline{OP}^2 = r^2+t^2_1$, $\overline{OQ}^2=r^2+t^2_2$, and $4R^2 = \overline{PQ}^2 = t^2_1+t^2_2$.

Therefore, by substitution and reduction, we obtain

$$\overline{OC}^2 = r^2+R^2,$$

which easily leads to the desired result.

Exercise 614 of Todhunter's *Euclid* can be proved by aid of Exercise 309 of the same work, and this in turn by means of well-known principles of elementary geometry.

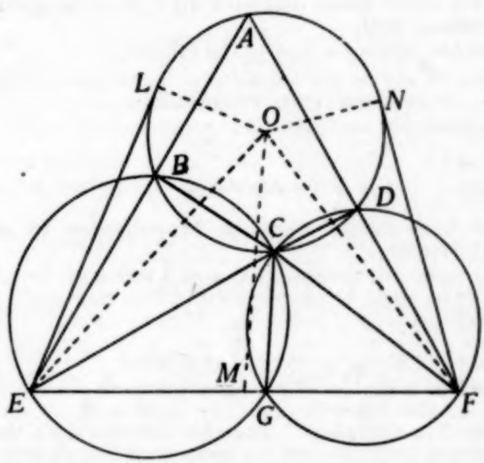
The error in 529 was also pointed out by R. M. MATHEWS.—*Ed.*

Geometry.

529. *Proposed by R. T. McGregor, Nord, Cal.*

The circle whose diameter is the third diagonal of a quadrilateral inscribed in another circle cuts the latter orthogonally.

Solution by E. L. Brown, Denver, Col.



Let ABCD be the cyclic quadrilateral, EF its third diagonal.

Draw FN, EL, tangents to circle O. Let M be mid-point of EF, hence center of circle on EF as a diameter.

We will first prove $\overline{EF}^2 = \overline{FN}^2+\overline{EL}^2$.

About CDF describe a circle CDFG, cutting EF in G. Join CG.

The angles BAD, BCD are supplementary; also the angles DFG, DCG are supplementary. Therefore the angles BAD, BCD, DFG, DCG together make four right angles. The angles BCD, BCG, DCG also make four right angles. Therefore, BCG = BAD+DFG, and BCG+BEG = EAF+AFE+AEF. Hence angles BCG and BEG are supplementary, and BCGE is a cyclic quadrilateral. Therefore FE · EG = DE · EC = $\overline{EL}^2$, and EF · FG = BF · FC = $\overline{FN}^2$. But FE · EG+EF · FG = $\overline{EF}^2$.

Therefore $\overline{EF}^2 = \overline{FN}^2+\overline{EL}^2$.

Now let OL = ON = r, and EM = MF = R. Join O to L, N, F, M, E.

$$\overline{EL}^2 = \overline{EO}^2 - r^2, \text{ and } \overline{FN}^2 = \overline{OF}^2 - r^2.$$

$$\therefore \overline{EL}^2 + \overline{FN}^2 = \overline{EO}^2 + \overline{OF}^2 - 2r^2.$$

$$\overline{EO}^2 + \overline{OF}^2 = 2\overline{OM}^2 + 2R^2.$$

$$\therefore \overline{EL}^2 + \overline{FN}^2 = 2\overline{OM}^2 + 2R^2 - 2r^2.$$

$$\text{But } \overline{EL}^2 + \overline{FN}^2 = \overline{EF}^2 = 4R^2.$$

$$\therefore 4R^2 = 2\overline{OM}^2 + 2R^2 - 2r^2.$$

$$\therefore \overline{OM}^2 = R^2 + r^2.$$

Hence circles whose centers are O and M are orthogonal.

II. *Solution by Nelson L. Roray, Metuchen, N. J.*

Let A, B, C, D be four points on the circumference of a circle, and let connectors AD and BC intersect at G, the connectors CD and AB intersect at F, the connectors BD and AC at E.

Then EFG is a self conjugate triangle (Lachlan's *Modern Pure Geometry*, §270).

Hence, G is the pole of EF and F is the pole of GE, and G and F are conjugate points with respect to the given circle.

Therefore, the circle whose diameter is FG cuts the given circle orthogonally. (Lachlan, §260).

NOTE: Problem 529 is one case of the following:

Circles whose diameters are the sides of the central tetrastigen inscribed within a circle cut the given circle orthogonally.

One incorrect solution received.—Ed.

Algebra.

542. *Selected from College Entrance Examinations (September, 1917), Advanced Algebra.*

How many numbers between 100 and 1,000 may be formed from 0, 1, 2, 3, 4, 5, 6, no digit being repeated in any number? How many of these are even?

I. *Solution by L. E. Lunn, Heron Lake, Minn.*

As the problem is stated, three place numbers are required. For the first place, i. e., the hundreds digit, we have only six choices, since we cannot use the 0 in this place. Then for the tens digit there remain six numbers to choose from, and for the units digit five choices.

The total number of numbers is then 6x6x5 or 180.

Since 0 cannot be used in hundreds place, there are three even and three odd digits for use in this place. Then just half, or 90 of the numbers will have an even number in hundreds place.

Of the 90 numbers having an even number in hundreds place there will remain three even numbers for units place, and 1, 3, and 5 odd numbers in units place. This will give just half of these 90 numbers even and half odd. There are then 45 even numbers in this group.

Of the 90 numbers having an odd number in hundreds place, there remain 0, 2, 4, and 6, even numbers, and but two odd digits for use in units place. Then two-thirds of this group will be even. This gives 60 even numbers out of this group.

There will then be a total of 105 even numbers in the 180 three place numbers.

Writing the numbers verifies this result.

II. *Solution by R. M. Mathews, Riverside, Cal., and R. T. McGregor, McArthur, Cal.*

Using the notation ${}_nP_m$ for permutations of n things m at a time, we have,

Numbers without zero: ${}_6P_3 = 120$
Numbers with zero tens: ${}_6P_2 = 30$
Numbers with zero units: ${}_6P_2 = 30$

Total --------------------180 numbers.

Since half the digits are even and half odd, just half the first group will end in an even digit and so be even numbers. All of the last group will be even. Thus 105 of the 180 will be even numbers.

Also solved by C. E. Githens.—*Ed.*

Geometry.

543. *Selected from College Entrance Examinations* (*September, 1917*), *Elementary Geometry.*

If ABC is a right triangle with the right angle at B, and if D is a point on AC such that AB is the mean proportional between AC and AD, prove that ADB is a right angle.

I. *Solution by Geo. H. Olson, Nevis Minn.* (*Solutions differing from this only in minor details received from Edward S. Mooney, South Dayton, N. Y., W. W. Gorsline, Chicago, Isidore Ginsberg, New York City, and R. M. Mathews, Riverside, Cal.*

Join D with A. The triangles ABC and ADB are similar, having an acute angle of the one equal to an acute angle of the other, and the including sides proportional. Similar triangles have their corresponding angles equal, hence angle ADB is equal to angle ABC. Angle ABC is by hypothesis a right angle, hence angle ADB is a right angle.

II. *Solution by Grover C. Koffman, Hopkinsville, Ky.*

If BD is not perpendicular to AC, draw BM perpendicular to AC.

Then

$$\overline{AB}^2 = AC \cdot AM.$$

But

$$\overline{AB}^2 = AC \cdot AD.$$

Therefore, AD coincides with AM and BD is perpendicular to AC.

III. *Solution by L. E. Lunn.*

Given: Right triangle ABC, and point D on AC, and $(AB)^2 = AC \times AD$.

To prove: $\angle ADB = 90°$.

Proof:

1. $\overline{AB}^2 = AC \times AD$
2. Then $\dfrac{AB}{AD} = \dfrac{AC}{AB}$ (dividing Equation 1 by $AB \times AD$)
3. Then DB and BC are either parallel or anti-parallel. (Two lines which cut off proportional sects from the sides of an angle are either parallel or anti-parallel, and the triangles formed are co-sensal or non-co-sensal respectively.)
4. It then follows that DB and CB are anti-parallel and that the triangles are similar non-co-sensal triangles.
5. Since $\angle B$ is given a right angle, then by 4 it follows that $\angle D$ is also a right angle.

Solutions were also received from Nelson L. Roray, R. T. McGregor, M. T. Nolan, *and* Ernest H. H. Sanger. *A second solution was received from* Geo. H. Olson.—*Ed.*

Trigonometry.

544. *Proposed by Clifford N. Mills, Brookings, So. Dak.*

The angles of a plane triangle form a geometrical progression of which the common ratio is 1/2. Show that the ratio of the greatest side to the perimeter is 2 $\sin\pi/14$.

I. *Solution by R. M. Mathews, Riverside, Cal.*

Let 4α, 2α, α be the angles of the triangle. Then $\alpha = \pi/7$.

By the law of sines:

$$\frac{a}{\sin 4\pi/7} = \frac{b}{\sin 2\pi/7} = \frac{c}{\sin \pi/7},$$

whence by composition and alternation

$$\frac{a}{a+b+c} = \frac{\sin 4\pi/7}{\sin 4\pi/7 + \sin 2\pi/7 + \sin \pi/7}$$

Replace $\sin\pi/7$ by its equal $\sin 6\pi/7$ and use the formula for the sum of two sines and we have

$$= \frac{\sin 4\pi/7}{\sin 4\pi/7 + 2\sin 4\pi/7 \cos 2\pi/7} = \frac{1}{1 + 2\cos 2\pi/7}$$

Substitute $\sin 4\pi/7 / \sin 2\pi/7$ for $2\cos 2\pi/7$ and simplify:

$$= \frac{\sin 2\pi/7}{\sin 2\pi/7 + \sin 4\pi/7} = \frac{2\sin\pi/7 \cos\pi/7}{2\sin 3\pi/7 \cos\pi/7}$$

$$= \frac{\sin\pi/7}{\sin 3\pi/7} = \frac{2\sin\pi/14 \cos\pi/14}{\cos\pi/14} = 2\sin\pi/14.$$

$(\sin 3\pi/7 = \cos(\pi/2 - 3\pi/7) = \cos\pi/14)$.

II. *Solution by E. L. Brown, Denver, Col.*

In any triangle

$$\frac{a+b}{c} = \frac{\sin A + \sin B}{\sin C} = \frac{\sin\frac{1}{2}(A+B)\cos\frac{1}{2}(A-B)}{\sin\frac{1}{2}C\cos\frac{1}{2}C} = \frac{\cos\frac{1}{2}(A-B)}{\cos\frac{1}{2}(A+B)} \qquad (1)$$

Adding unity to each member of (1),

$$\frac{a+b+c}{c} = \frac{\cos\frac{1}{2}(A+B) + \cos\frac{1}{2}(A-B)}{\cos\frac{1}{2}(A+B)} = \frac{2\cos\frac{1}{2}A\cos\frac{1}{2}B}{\sin\frac{1}{2}C} \qquad (2)$$

Let $B = \frac{1}{2}C$, $A = \frac{1}{4}C$.

Then $A+B+C = 7C/4 = \pi$.

$\therefore C = 4\pi/7, B = 2\pi/7, A = \pi/7.$ (3)

From (2) and (3),

$$\frac{a+b+c}{c} = \frac{2\cos\pi/14\cos\pi/7}{\sin 2\pi/7} = \frac{\cos\pi/14}{\sin\pi/7} = \frac{1}{2\sin\pi/14}.$$

III. *Solution by Murray J. Leventhal, New York City.*

Let $4x$, $2x$, and x be the angles of the triangle, so that the corresponding opposite sides may be represented by $d\sin 4x$, $d\sin 2x$, and $d\sin x$, where d is a constant. Then,

$$\begin{aligned} \text{the greatest side : perimeter} &= \sin 4x : (\sin 4x + \sin 2x + \sin x) \\ &= \sin 4x : 4\cos 2x \cos x \cos x/2 \\ &= 2\sin x/2 = 2\sin\pi/14, \end{aligned}$$

since from the hypothesis, $7x = \pi$ and $x = \pi/7$.

Solutions were also received from C. E. Flanagan, Isidore Ginsberg, W. W. Gorsline, L. E. A. Ling, Nelson L. Roray, *and* Samuel Wolff. —*Ed.*

545. *Proposed by Nelson L. Roray, Metuchen, N. J.*

Express $\sin^2\alpha+\sin^2\beta+\sin^2\gamma-2\sin\alpha\sin\beta\sin\gamma-1$ as the product of four cosines.

I. *Solution by E. L. Brown, Denver, Col.*

$$\mathrm{Sin}^2\alpha+\sin^2\beta+\sin^2\gamma-2\sin\alpha\sin\beta\sin\gamma-1 =$$
$$(\sin\alpha-\sin\beta\sin\gamma)^2-\sin^2\beta\sin^2\gamma+\sin^2\beta+\sin^2\gamma-1 =$$
$$(\sin\alpha-\sin\beta\sin\gamma)^2-(1-\sin^2\beta)(1-\sin^2\gamma) =$$
$$(\sin\alpha-\sin\beta\sin\gamma)^2-(\cos\beta\cos\gamma)^2 =$$
$$(\sin\alpha-\sin\beta\sin\gamma-\cos\beta\cos\gamma)(\sin\alpha-\sin\beta\sin\gamma+\cos\beta\cos\gamma) =$$
$$[\cos(90-\alpha)-\cos(\beta-\gamma)][\cos(90-\alpha)+\cos(\beta+\gamma)] =$$
$$-4\sin\left(\frac{90-\alpha+\beta-\gamma}{2}\right)\sin\left(\frac{90-\alpha-\beta+\gamma}{2}\right)\cos\left(\frac{90-\alpha+\beta+\gamma}{2}\right)\cos\left(\frac{90-\alpha-\beta-\gamma}{2}\right) =$$
$$-4\cos\left(\frac{90+\alpha-\beta+\gamma}{2}\right)\cos\left(\frac{90+\alpha+\beta-\gamma}{2}\right)\cos\left(\frac{90-\alpha+\beta+\gamma}{2}\right)\cos\left(\frac{90-\alpha-\beta-\gamma}{2}\right).$$

II. *Solution by the Proposer.*

$$\sin^2\alpha+\sin^2\beta+\sin^2\gamma-2\sin\alpha\sin\beta\sin\gamma-1 = \sin^2\alpha+\sin^2\beta-\cos^2\gamma-2\sin\alpha\sin\beta\sin\gamma$$
$$= \sin^2\alpha-\cos(\beta+\gamma)\cos(\beta-\gamma)-2\sin\alpha\sin\beta\sin\gamma$$
$$= \sin^2\alpha-\cos(\beta+\gamma)\cos(\beta-\gamma)-\sin\alpha[\cos(\beta+\gamma)-\cos(\beta-\gamma)]$$
$$= [\sin\alpha+\cos(\beta+\gamma)][\sin\alpha-\cos(\beta-\gamma)]$$
$$= [\cos(\pi/2-\alpha)+\cos(\beta+\gamma)][\cos(\pi/2-\alpha)-\cos(\beta-\gamma)]$$
$$= -4\left[\cos\left(\frac{\alpha+\beta+\gamma}{2}-\frac{\pi}{4}\right)\cos\left(\frac{\pi}{4}+\frac{\beta+\gamma-\alpha}{2}\right)\cos\left(\frac{\pi}{4}+\frac{\alpha+\beta-\gamma}{2}\right)\cos\left(\frac{\pi}{4}+\frac{\alpha+\gamma-\beta}{2}\right)\right].$$

One incorrect solution was received.—Ed.

PROBLEMS FOR SOLUTION.

Algebra.

556. *Proposed by L. E. Lunn, Heron Lake, Minn.*

A fast half back finds himself free with the ball 40 yds. from the side line. Thirty yards ahead of him is his only opponent, a slower man, whom he knows he can outrun by four feet to three feet. Can he escape? If not how should he lay his course to gain the most ground before being tackled?

Geometry.

557. *Proposed by Clifford N. Mills, Brookings, S. Dak.*

If ABC is a triangle inscribed in a circle, and from the middle point D of the arc BC a perpendicular DE is drawn to AB, then AE = 1/2 (AB+AC) and BE = 1/2 (AB−AC).

558. *Proposed by Murray J. Leventhal, New York City.*

From a given point without a triangle to draw a line bisecting the triangle.

559. *Proposed by N. P. Pandya, Sojitra, B. B. & C. I. Ry., India.*

Construct a triangle, having given a side, an angle adjacent to it, and the difference of the medians through its extremities.

560. *Proposed by I. N. Warner, Plattesville, Wis.*

Show that the following construction does, or does not, give a regular pentagon.

To a given side AB construct RP perpendicular to its mid-point, R, and equal to AB. Draw AP and extend it to S, making PS = AR. With A as center and AS as radius draw an arc cutting RP extended, at D. A, B, and D are three of the required vertices, and AB a given side, so that C and E are easily determined by using the compasses. Then is ABCDE a regular pentagon?

SCIENCE QUESTIONS.

Conducted by Franklin T. Jones,
University School, Cleveland, Ohio.

Readers are invited to propose questions for solution—scientific or pedagogical—and to answer questions proposed by others or by themselves. Kindly address all communications to Franklin T. Jones, University School, Cleveland, Ohio.

Examination Papers.

The receipt of entrance examination papers is gratefully acknowledged from Amherst College, College Entrance Examination Board, Boston University, University of California, Columbia University, Cornell University, University of Illinois, Massachusetts Institute of Technology, McGill University, Mt. Holyoke College, University of Pennsylvania, Rensselaer Polytechnic Institute, Stevens Institute of Technology, University of Toronto, Trinity College, Wellesley College, and Williams College.

Please send examination papers on any subject or from any source to the Editor of this department. *He will reciprocate by sending you such collections of questions as may interest you and be at his disposal.* **Send your first term examination now.** If a representative number of papers in physics, chemistry and other sciences can be obtained, the Editor will attempt a comparison of school with college entrance examinations.

[**Please note carefully.**—The Editor does not assume that they should be the same or even correspond.]

Science Tests.

In May, 1917, question number 269 was published for the express purpose of arousing interest in science testing. The following have expressed a desire to cooperate in working on the problem: A. B. Bucknam, Crosby H. S., Waterbury, Conn.; Miss Jessie Caplin, West H. S., Minneapolis, Minn.; H. Lawton Chase, Claremont, N. H.; Miss Annie Cloyd, Sewickley, Pa.; Lewis H. Fee, Everett H. S., Everett, Wash.; P. C. Hyde, Newark Academy, Newark, N. J.; Walter N. Lacy, Anglo-Chinese College, Foochow, China; L. E. Lunn, Heron Lake, Minn.; S. R. Powers, University H. S., Minneapolis, Minn.; Hanor A. Webb, Peabody Col. for Teachers, Nashville, Tenn.; T. R. Wilkins, University H. S., Chicago, Ill.

Will the above, or others who are interested in physics, please notify the Editor how soon they could use some testing material on heat? On light? On electricity? On sound? On mechanics? Can you get data also from other classes than your own?

Likewise in chemistry?

General Science.

Please send to the Editor of this department an outline of your course in general science. In what year or years is the subject taught? Would

two years of general science two or three periods per week be better than one year five periods per week? Has your course in general science a unifying principle? If so, what is it?

Send your examination paper in general science.

Questions and Problems for Solution.

295. *Proposed by S. R. Powers, Minneapolis, Minn.*

"We find, as we continue to dilute an electrolyte, that the molecular conductivity increases up to a certain point beyond which it does not change. This might be expected for, at a certain dilution, *all* the molecules are dissociated and a further dilution causes no further dissociation." [Quoted from a recent high school test.]

Is this true? Is 100% dissociation attained?

296. *Proposed by G. Ross Robertson, Polytechnic H. S., Riverside, Cal.*

We are told that a wet object dries faster on a dry day than on a humid day because, at the former time, the air has a large reserve capacity for water-vapor. If this is so, why does an object wet with varnish dry faster on a dry day than on a humid day? It must be noted that on neither day does the air contain turpentine vapor—the volatile substance involved.

297. *Proposed by J. C. Packard, Brookline, Mass.*

Will a siphon work in a vacuum?

[Mr. Packard says that "a professor in ——— University stated a few years ago, in my hearing, that he had tried the experiment and that the siphon did work up to a height of (about) 20 inches owing to the cohesion of the water." Try it.]

SOLUTIONS AND ANSWERS.

275. *Proposed by Daniel Kreth, Wellman, Iowa.*

A stream of water, 4 feet deep, flows at the rate of 5 ft. per second. It is required to lower the water by means of a "drop" so that the bottom of the stream below the "drop" is 4 ft. lower than it is above the "drop." What must be the dimensions of the pit below the "drop" so that the water acts as a cushion to prevent the water striking the ground?

Answered by Arthur E. Morgan, Chief Engineer, Miami Conservancy District, Dayton, Ohio.

Belassis in "River and Canal Engineering," p. 113, gives a formula for the depth. [The answer in full has been sent to Mr. Kreth. Those interested may correspond directly with him. EDITOR.]

279. *Proposed by John C. Packard, Brookline, Mass.*

Can a real image be formed by the action of a plane mirror? [Suggestion—Consider the use of a plane mirror in connection with the reflectoscope.]

Answered by F. T. Jones.

A real image cannot be formed by a plane mirror but the mirror may be used to change the direction of rays of light, whether parallel rays, or converging, or diverging. In the reflectoscope the mirror changes the direction of all the rays that fall upon it without changing their properties. If converging to form a real image before plane reflection, they remain converging afterwards.

280. *Proposed by A. Haven Smith, Riverside Junior College, Riverside, Cal.*

A cylindrical shaft 4 inches in diameter, weighing 80 lbs., turns without friction about a horizontal axis. A fine cord is wrapped around it by which a 20-lb. weight hangs. How long will the weight take to descend 12 feet?

Solved by Wm. F. Rigge and J. P. Drake.

Solution by Wm. F. Rigge.

I think the whole subject of moment of inertia as given in our textbooks is generally too repellantly abstruse for students. The formula I use is as simple, I think, as it can be made. Thus we have the moment of inertia $= K = Fb/\alpha$, in which F is the force causing rotation, b its lever arm, Fb then the moment, and α the angular acceleration.

If m = pulling weight attached to the cord, its own acceleration in falling, g, is diminished by the acceleration a it must give to the shaft, so that $F = m(g-a)$. But $a = r\alpha$, and $\alpha = a/r$, hence

$$K = \frac{Fb}{\alpha} = \frac{m(g-a)r}{\alpha} = \frac{m(g-a)r}{a/r} = \frac{mr^2(g-a)}{a}.$$

If a = the length of cord unwrapped more every second = acceleration of the falling weight, the theoretical moment of inertia $K = 1/2Mr^2$ is equal to the observational one of $mr^2(g-a)/a$. This gives $a = 10\ 2/3$ feet in the present case. Then from the formula $s = 1/2at^2$, t is found to be 1 1/2 seconds.

This is the method the writer uses to find moment of inertia. Instead of the cumbersome and expensive blackened and graduated heavy disk, with its tuning fork and microscopes, he replaces the pulley of his Atwood's machine by a wooden disk and finds the acceleration a either directly or through the formula $s = 1/2\ at^2$.

282. *Proposed by W. A. Hedrick, Washington, D. C.*

Why not adopt metric measurements as the *sole* standard of units?

Answer by L. E. Lunn, Heron Lake, Minn.

For general use there is probably no reason against the general adoption of the metric system other than conservatism, which sees an immediate loss in discarding present measuring instruments standardized in other systems, and in operatives familiarizing themselves with a new system.

On the other hand, counting out the general recognized simplicity of operation, there is another and greater advantage in having a single standard of value the world over. This one fact would do a great deal toward bringing all nations closer together and would make international commerce a less complicated matter. There is indeed no intrinsic reason why we English speaking peoples cannot buy coal by the metric ton, butter and sugar by the kilogram, diamonds and gold by the milligram, take our medicine by the cubic centimeter, etc., throughout our daily life. There is one problem in the agricultural region of this country that will probably never fit into the metric system and that is the problem of land measurement. Our land is largely surveyed on a well organized plan based on the square mile as a unit. This could not well be changed.

Summarizing, then, we find that there is no real objection to the metric system outside the one mentioned problem, and that need not interfere with any other application. It is my own personal belief that we will in the near future see a general adoption of the metric system.

Comment by a superintendent at The Warner & Swasey Company.

The obstacle lies in the men. They are willing to work in English units but are unwilling to change.

283. *Proposed by R. A. Burtnett, Champaign, Ill.*

A 40-watt lamp burns for one hour immersed in 10 liters of water which is at 10° C. at the time the lamp is turned on. If lamp is 16 per cent efficient as a light, find the second temperature at the end of the hour.

Solved by A. H. Smith and J. P. Drake.

Solution by J. P. Drake, Emporia, Kans.

The light efficiency = 16%.

∴ the heat efficiency = 84%.

H = .24 × watts × time in seconds.

$H = .24 \times (40 \times .84)3600 = 29030$ calories.

Rise in temperature $= 29030/10000 = 2.9°$ C.

$\therefore$ Final temperature $= 12.9°$ C.

284. *Proposed by William T. Reed, Woodlawn, Pa.*

Do you think it advisable to have all laboratory notes done in the "Lab."?

Answer by A. H. Smith, Riverside, Cal.

We think it advisable to have all laboratory work done in the laboratory. We have tried both plans, that is, all work done in the laboratory and as much as possible in the laboratory and the remainder at home.

We like the former for two reasons: It tends to keep the pupil from dilly-dallying over his task, and the temptation to copy is greatly reduced. We have found it necessary in some instances to cut down the number of trials required in a given experiment. We believe, however, the advantages of requiring that all the work be done in the laboratory greatly outnumber the few disadvantages.

Answer by J. P. Drake.

I am convinced that the notes should all be made in the laboratory and handed to the instructor as soon as completed.

285. *Proposed by M. W. Arps, U. S. S. Ohio, c-o Postmaster, New York.*

"A" claims that if two balls of equal diameter, but of different material, one being lead and the other wood, be dropped in air from a height of one mile, that they would both reach the ground at the same time.

"B" claims that the lead ball would reach the ground first. Which is correct?

Answer by L. E. Lunn, Heron Lake, Minn.

This question ignores the fundamental statement of the laws of gravitation. The statement of the laws of gravitation includes no other force acting on the body under consideration than that of the earth's gravitation. In this problem the resistance of the air exerts a retarding influence on both. The greater mass of the lead ball, however, gives it a greater momentum which overcomes the resistance of the air to a greater extent than does the wood ball. If the density of the wood be decreased indefinitely it will be found that as the density of the wood approaches the density of the air that its velocity will decrease and will approach zero.

Using distances less than about one hundred feet the writer has found that it is almost impossible to detect any difference in the fall of two such objects. Above this distance the difference is quite plainly apparent.

This same fact can be very plainly demonstrated by using a long glass tube (two meters in length is sufficient) filled with water. The writer recently used this method in his physics class, using an aluminum ball and a lead ball. The heavier ball reaches the bottom in much less time than the lighter one.

It should also be noted that as the velocity increases the resistance increases in a cubic ratio. This then is the reason why the difference is apparent only after some considerable distance of fall.

Answer by Annie Cloyd, Sewickley, Pa.

Barring the effect of the air, the balls will reach the ground at the same time, since all bodies fall with equal velocities except for the resistance of the air. Hence A was right.

Answer by Tracy F. Tyler, Wood River, Neb.

Both balls should reach the ground at the same time. Both balls should fall at the same rate.

RESEARCH IN PHYSICS.

Conducted by Homer L. Dodge.

State University of Iowa, Representing the American Physical Society.

It is the object of this department to present to teachers of physics the results of recent research. In so far as is possible, the articles and items will be nontechnical, and it is hoped that they will furnish material which will be of value in the classroom. Suggestions and contributions should be sent to H. L. Dodge, Department of Physics, State University of Iowa, Iowa City, Iowa.

ONE OF THE PROOFS THAT MATTER IS MOSTLY EMPTY SPACE.

One of the most interesting results of the recent discoveries of physics is the proof that any particular piece of matter is composed mostly of empty space. The idea that matter is the solid, substantial stuff which our senses reveal must give way before the more discriminating insight furnished by the kinetic theory. In fact, experiments and other proofs that molecules and atoms are in ceaseless motion, and that they are separated by comparatively large distances, have been familiar for many years.

But the molecule and the atom were still regarded as very substantial things. Even when the electron was discovered it was spoken of as something knocked off from the atom like a tiny nick from the surface of a marble. It was many years before the cloud of mystery enveloping the atom was at all dispelled. Recently, there have been striking and convincing proofs that the atom itself has but little within its boundaries that can be called matter.

One of the lines of investigation that have led to the conclusion that matter is nearly all empty space grew out of the work of C. T. R. Wilson. It was in 1912 that he first published photographs of the passage of α and β-particles through gases.[1]

The apparatus, like so much of that with which important work is done, is relatively simple. There was a source of α and β-particles, usually radium, which shot them through a chamber of moist air so arranged that the air could be easily expanded. On the expansion of the saturated air the moisture would collect on the ions[2] produced by the radioactive particles, and these drops of water were photographed.

In this way it was found that the α-particles ionize the gas to such an extent that their trails are marked by continuous rows of droplets showing upon the photographs as long straight lines, with here and there a sharp bend. The β-particles, on the other hand, produce for the most part isolated pairs of droplets. One of the pair is associated with the electron and the other with the positive portion of the atom. If we examine into the reasons for these effects we are led to interesting conclusions.

The α-particles are, as is well known, atoms of helium, and being heavy (four times the atomic weight of hydrogen) possess considerable energy even though they travel at a speed much slower than that of the electron. The β-particles have a mass approximately one two-thousandth of that of the hydrogen atom. Consequently, even though they travel at high speeds, they have very much less energy than the α-particles, and are

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[1]C. T. R. Wilson, Proc. Roy. Soc., London, 87, 277, 1912. Four of the photographs are reproduced in *The Electron* by R. A. Millikan from which we quote freely in this article, and two are to be found in *A First Course in Physics* by Millikan and Gale.

[2]Saturated water vapor will condense readily on ions and dust particles. When the air is dust free, each ion will, under the proper conditions, become the nucleus upon which a water droplet condenses.

therefore less active in producing ionization of the gas through which they pass.

The big, slow-moving α-particle lumbers along and has plenty of time to disturb vast numbers of gas molecules and has sufficient energy to produce a great deal of ionization before anything happens to seriously disturb its own progress. The small, rapidly moving electron, or β-particle, dashes through so rapidly that it must come almost face to face with one of the electronic constituents of an atom in order to dislodge it and thus produce ionization.

One of the photographs which have been mentioned shows a series of a dozen pairs of specks lying in a straight line. These are the droplets which reveal the ionization from a single β-particle. Since the size of the molecule is known and the number per cubic centimeter, the number through which the β-particle must pass in going a given distance can be computed. The extraordinary situation revealed by this photograph is that this particular particle shot through as many as 10,000 atoms before it came near enough to any electronic constituent of any one of these atoms to detach it from its system and form an ion. This shows conclusively that the electronic or other constituents of atoms can occupy but an exceedingly small fraction of the space enclosed within the atomic system. Practically the whole of this space must be empty to an electron going with this speed.

Other photographs show the tracks of negative electrons of much slower speed and the curved paths and closer drops show that slow β-particles ionize much more frequently and are themselves deflected in the process. This can be readily understood from the following illustration. If a new planet or other relatively small body were to shoot with stupendous speed through our solar system, the time which it spent within our system might be so small that the force between it and the earth, or other member of the solar system, would not have time either to deflect the stranger from its path or to pull the earth out of its orbit. If the speed of the strange body were less, however, the effect would be more disastrous both to the constituents of our solar system and to the path of the strange body, for the latter would then have a much better chance of pulling one of the planets out of our solar system and also a much better chance of being deflected from a straight path itself. The more slowly a negative electron moves, then, the more is it liable to deflection, and the more frequently does it ionize the molecules through which it passes.

Turning now to the α-particles one finds that Wilson's photographs show that they shoot in straight lines through from three to seven centimeters of air before they are brought to rest. This means that an atom has so loose a structure that another atom, if endowed with enough speed, can shoot right through it, in some cases detaching an electron and in others producing no effect which can be detected. That the α-particle goes right through the atoms which it encounters is shown by the fact that it ionizes several times more violently toward the end of its path than toward the beginning, and it therefore loses energy more rapidly when it is going slowly than when it is going rapidly. If it pushed the molecules aside, as a bullet does, the resistance to its motion would be the greatest when its speed was the highest.

Further, an α-particle is deflected more readily as it slows down. The photographs show sharp bends near the ends of the paths. This gives important evidence concerning the structure of the positive core of the atom. The α-particles, being about eight thousand times more massive than negative electrons, can produce the tremendous amount of ionization represented by the solid lines of droplets appearing in the photo-

graphs. The encounter with electrons produces no deviation in the path of the particle. What, then, is responsible for the sudden deflections? They can only be produced by a very powerful center of force within the atom whose mass is at least comparable with the mass of the helium atom, i. e., the α-particle. The fact that the photographs show that the α-particle goes through as many as 500,000 atoms without approaching near enough to the central nucleus to suffer appreciable deflection more than two or three times, constitutes the most convincing evidence that the central nucleus, which holds the negative electrons within the atomic system as the sun holds in their courses the planets of the solar system, occupies an exceedingly minute volume. The evidence which has been reviewed in this article shows the atom to be mostly "hole." The nature of the very small amount of matter present in the nucleus and other points in connection with atomic structure will be considered in a later issue.

THE FIRST INTEREST INSTALLMENT.

On December 15 the first installment of interest on the two billion dollars of the first issue of Liberty Loan bonds became due. The amount approximated $35,000,000, being $1.75 interest on every one hundred dollars of bonds.

Holders of coupon bonds obtain their interest money from any bank or post office in the country by simply presenting their coupons. Holders of registered bonds are sent checks for their interest by the Treasury.

Hereafter every six months ten to fifteen million American citizens are to receive interest money on their Liberty Loan bonds from the United States Government. This is going to create a closer and more direct association of these citizens with their Government, and the effect of this association is going to be of great value to these citizens and of great value to the nation in making them more personally interested in their Government and more active and alert in the exercise of their duties and rights as citizens. Every Liberty Bond holder is going to be an active champion of wise and economic legislation and administration.

The Liberty Loan is not only a great financial transaction; it is a great national force, a great national bond between the bondholders and their country, a great influence for better government and better citizenship.

ADVOCATES WATER-POWER LEGISLATION.

Noting the efforts of past years toward the enactment of legislation relating to the development of the water power of the nation, the Secretary of Agriculture, in his annual report, says that "it becomes increasingly urgent that amendments to existing law be made and that a well-rounded policy be decided upon." The report continues:

"The present industrial situation, and particularly the scarcity and high cost of fuel and construction materials, have increased the cost of steam power and make it highly important that action be taken at the next session of Congress. Legislation which will make it possible to safeguard the public interests, and at the same time to protect private investors, should result in securing cheaper water power and in conserving the coal and fuel-oil supply. Since three departments of the Government are vitally concerned in water-power legislation and its possible terms and would be vitally affected by the administrative handling of matters under such legislation, it would seem desirable to consider whether it is feasible to devise an executive body on which the three departments will be represented and which will be able to utilize to the best advantage all their existing agencies."

MINUTES OF THE EARTH SCIENCE SECTION OF CENTRAL ASSOCIATION OF SCIENCE AND MATHEMATICS TEACHERS.

Meeting of Section called to order by the chairman, W. R. McConnell, State Normal School, Platteville, Wis.

Announcements: Nominating Committee: Dr. Geo. D. Hubbard, Oberlin, Ohio; Miss Josephine Leach, Toledo University, Toledo, Ohio. Reception at Library at 4:30 p. m. Dinner, Oxley Hall, 6 p. m. Lecture at University Chapel at 8:15 p. m.; topic, "Mt. Katmai—The Mountain of 10,000 Smokes," Dr. Robert Griggs, Ohio State University.

Program: "The Home State as a Geographic Unit," D. C. Ridgeley, State Normal University, Normal, Ill.

A paper, "The Materials for the Geography of South America," Isaiah Bowman, Director of American Geographic Society, N. Y., was read by title only, Mr. Bowman not being present.

B. H. Schockel, State Normal School, Terre Haute, Ind., read an interesting paper on "The Geographic Influences in the French and Indian War."

The third speaker was Miss Josephine Leach of Toledo University, Toledo, Ohio, who spoke on "The Aims of Geography in the Elementary School." Miss Leach says geography is no longer a textbook only; the world of today must be brought into the classroom. Let the textbook be a book of reference. Use *topics*, as: South America. What are the natural controls? What helps? What hinders? What are the life responses to these natural controls? Compare South America with other continents. Groups of suggestive questions may be given, one or more to be chosen. Have some pivotal questions as, "Why is Africa the 'dark continent?' " Try to set up geographic concepts that may be used to measure and compare with other geographic matter as it comes to the attention of the student.

"The Aim and Content of Junior High School Geography," was discussed by W. M. Gregory, Normal Training School, Cleveland, Ohio. Mr. Gregory gave a suggestive course for the Junior High Schools; the work that is being tried out in Cleveland is the study of Cleveland—the geographic factors of its growth and development, its industries, people, trade, its needs and how they are supplied, its commercial products, the disposition of the same, etc.

After an animated discussion of all papers, the Section adjourned to meet again Saturday morning.

Saturday, December 1, 10 a. m.

Meeting called to order by President McConnell. Announcements, reports, etc.:

Excursions for afternoon: By automobile to filtration and garbage disposal plants. By interurban to glens worn in the shales of the upper Devonian; excursion conducted by Dr. John Bownocker, State Geologist.

Report of Nominating Committee, Dr. Hubbard, Chairman: Chairman for 1918, Mabel Stark, State Normal, Normal, Ill.; Vice-Chairman, C. H. Robinson, Montclair, N. J.; Secretary, Martha Linquist, Belvidere, Ill.; Chairman of Reception Committee, Eugene Van Cleef, Duluth, Minn.

Program:

"Reasons for Giving Geography a Greater Place in the High Schools," paper by Dr. Geo. D. Hubbard, Oberlin, O.

"Commercial Geography for the High Schools, Scope of a Unit Course," J. Paul Goode, Chicago University, Chicago, Ill.

A letter and partial report from J. H. Smith, Austin High School, Chicago, Ill., was read. Mr. Smith was chairman of a committee ap-

pointed in 1916 to outline a course of Earth Science work for the reorganized high schools. The committee had not yet worked out a course of study that would be suited to the high schools as they are now conducted—Junior and Senior High Schools. One fact agreed upon was that more time should be spent on the *social* aspects and less on the physical. The attention of the whole section was given to the partial report of the committee, all those present taking part in the discussion. The matter is considered of such importance now in this reorganization time in the high schools that a motion was made to continue the committee. Mr. Smith has sent word that it would not be possible for him to be chairman. The motion was therefore amended to read: "Resolved, That a committee be appointed to go on with the work so well begun, and to bring in next year a course of study in Earth Science that will be suited to the Junior and Senior High School courses. Carried, Committee will be announced later.

STELLA S. WILSON,
Secretary pro tem.

MINUTES OF THE MATHEMATICS SECTION OF THE CENTRAL ASSOCIATION OF SCIENCE AND MATHEMATICS TEACHERS.

November 30, 1917, 1:30 p. m.

The meeting convened with Mr. W. W. Hart of the University of Wisconsin in the chair, the general topic of discussion being mathematical aims and requirements.

Professor Harris Hancock, University of Cincinnati, read a paper on "What Course of Study Should be Taken by a Boy or Girl in High School "

Mr. Hart opened the discussion with the remark that there are educational aristocrats and educational democrats and that the judgment of the many is, in many things, of equal value to the judgment of the few.

Mr. Weaver of Ohio State University thought most of us miss the point of what to aim at in the educational scheme. Is it general education or special that is wanted? It is not so much subject matter as aims.

Mr. Comstock of Bradley Polytechnic Institute warned that the last word had not yet been said, that answers and questionnaires were not to be taken as final. If a man says mathematics gave him power of analysis then find out how much mathematics he had and what he did in the subject. A lawyer pinned down to answer whether geometry had helped, "Wasn't sure." Perhaps power came from other subjects. We must prove our point.

Further discussion was postponed until after Mr. Foberg's report from the Committee on Mathematical Requirements.

Report: The committee's work has been largely tentative as to: The value of mathematics for high school students; adaptation necessary to assure results but actual in the study of: Valid aims in teaching mathematics; bases of objection to mathematics; formal discipline, transfer of training, coefficient of correlation.

Mr. Foberg put much emphasis on the need of proving our point, not merely saying that mathematics is good for a student but showing why.

Investigation in the question of "transfer" has shown that much of the objection has been loudly voiced without foundation in proof. Miss Blair finds many instances of "transfer" and means are developing for showing coefficient of correlation between two subjects.

Mr. Foberg presented four suggestions for consideration. Each with the action taken by the Section is given:

1. The Section should have a cooperating committee for the coming year. Same committee was continued.

2. There should be one year of required mathematics for every boy and girl. Discussion: The Section seemed to feel this a lowering of standard until reports showed many schools where no mathematics is required. Final action was not taken.

3. Steps should be taken by Section to bring about revision of college entrance requirements. Discussion showed that students who have had only one year of mathematics try for exams for which prerequisite is two years. Also college entrance requirements in one section of the country dominate requirements for the whole and form an insurmountable difficulty to improvement in mathematics teaching. Work was referred to the general committee at the suggestion of Miss Sykes.

Mr. Comstock's motion carried: That the Publicity Committee take steps to spread the findings of the Committee on Requirements before superintendents and principals at their meeting and in whatever other way they deem possible or advisable in conference with a similar committee of the American Mathematics Association.

4. The actual condition in regard to findings about formal discipline should be spread abroad. The Section approved the suggestion and asked to have information sent to others than mathematics people as well as to those naturally interested.

Committees appointed: Nominating Committee—Mr. Cobb, Chairman; Mr. Davis. Committee on Finance—Mr. Comstock, Chairman; Mr. Crandall, Miss Hunt.

Saturday Morning Session.

The Saturday morning meeting was addressed by Mr. S. A. Courtis, Supervisor of Educational Research, Detroit, Michigan, on "Measurement of Products ot Teaching High School Mathematics."

In the discussion which followed, valuable suggestions were given as to tests which teachers could make at the present time. Reference was made to the book, "Educational Tests and Standards," by Walter S. Munro (published by Houghton Mifflin Company).

The report of Committee on First Year Mathematics was submitted, briefly discussed and referred again to the committee for completion, with the suggestion that copies be put in the hands of every member of the Section and each member send in suggestions as to changes.

Committee reports: Nominating Committee, Mr. Foberg, Chairman; Mr. Crosby, Vice-Chairman; Miss Atkin, Secretary.

Ballot ordered cast by Secretary.

ETHEL JAYNES,
Secretary pro tem.

SOUTHERN CALIFORNIA SCIENCE AND MATHEMATICS ASSOCIATION MEETING OF DECEMBER 20, 1917.

The nineteenth semi-annual meeting of the Southern California Science and Mathematics Association was held on December 20, 1917, in the science building of the Manual Arts High School, Los Angeles, Cal.

Only one afternoon was given to the general session as well as the Section meetings, as the Association meeting was held in connection with the combined institutes of the Los Angeles City and county. These furnished a large and varied program continued throughout the week of December 17 to 21. About a hundred members were present and a very interesting and profitable program was enjoyed.

The chief speakers on the program were Dr. Babcock, who has been associated with George Ellery Hale in his work on the Council of De-

fense, and Professor Laird Stabler of the University of Southern California, a recognized authority on petroleums. Their subjects, "Science and the War" and "Synthetic Gasoline" give some indication of the interest with which they were received by the audience.

At the business meeting which followed, the following officers were elected for the ensuing year.

President—Miss Agnes Wolcott, Long Beach High School.
Vice-President—Prof. E. E. Chandler, Occidental College.
Secretary-Treasurer—Miss Harriett S. King, Pasadena High School.

The following officers were reported elected at the meetings of the various Sections:

Mathematics Section.

Chairman—Prof. Paul Arnold, University of Southern California.
Secretary—Mrs. E. C. Farnum, Manual Arts High School, Los Angeles.

Earth Science Section.

Chairman—Mrs. Helen V. Peasley, 14th St. School, Los Angeles.
Secretary—Miss Minnie Reed, Berendo Int. School, Los Angeles.

Biology Section.

Chairman—L. R. Longworthy, Manual Arts High School, Los Angeles.
Secretary—Miss Grace M. Abbott, Venice High School.

Physics-Chemistry Section.

Chairman—A. Haven Smith, Riverside High School.
Secretary—C. W. Gray, Hollywood High School.

CLASSROOM SAYINGS.

The Zoologist's Requiem.

Oh, when I die don't bury me at all,
Just pickle my bones in alcohol.
Put a bottle of ——— (formalin) at my head and feet,
Then leave me alone, I guess I'll keep.

—[Anon.

"Kerosene emulsion is used for cleaning the carpet beetle and washing the floor so that they might not appear. It may be used for cleaning bedbugs also."

"Ichneumon fly is a parasite living on caterpillars. It stings the caterpillar and stays with its head buried until the caterpillar is dead."

"Beeswax is made by the workers. When the workers eat a lot of honey they sit still for a long time and wax forms in their wax pockets."

ARTICLES IN CURRENT PERIODICALS.

American Mathematical Monthly, for December; *5548 Kenwood Ave., Chicago; $3.00 per year:* "Cavalieri's Theorem in his own Words," George W. Evans; "Mathematical Forms of Certain Eroded Mountain Sides," T. M. Putnam; "The Obsolete in Mathematics," G. A. Miller; "A Substitute for Dupin's Indicatrix," C. L. E. Moore; "The Work of the National Committee on Mathematical Requirements," J. W. Young.

Geographical Review, for February; *Broadway at 156th Street, New York City; $5.00 per year, 50 cents a copy:* "The Eskimos of Northern Alaska: "A Study in the Effect of Civilization, "Diamond Jenness. (1 map, 7 photos); "The Isolation of the Lower St. Lawrence Valley," Roderick Peattie. (1 map, 8 photos); "Our Waterway Requirements," Robert M. Brown; "Ocean Temperatures Off the Coast of Peru," R. E. Coker; "Some Chinese Contributions to Meteorology," Co-Ching Chu; "New Evidence That Cook Did Not Reach the Pole."

Journal of Geography, for February; *Madison, Wis.; $1.00 per year, 15 cents a copy:* "A Comparison of Transportation on the Mississippi Basin Rivers and the Great Lakes," A. E. Parkins; "The Nitrate Industry of Chile," W. R. McConnell; "Physiography as a Basis for Commercial Geography, Botany, and History," Alison E. Aitchison; "A Neglected Duty of the Geography Teacher," Hannah Lindahl; "Minneapolis Outline for Teaching Japan and China."

Nature-Study Review, for January; *Ithaca, N. Y.; $1.00 per year, 15 cents a copy:* "The Striped Gopher," E. L. Palmer; "Animal Tracks," Robert W. Hegner; "The Odoriferous Skunk," Wm. E. Ringle; "Winter Sleepers," Editha S. Campbell; "The Snake," G. T. K. Norton.

Physical Review, for January; *Ithaca, N. Y.; $6.00 per year, 60 cents a copy:* "The Geometry of Image Formation in X-Ray Analysis," Horace S. Uhler; "The Ratio of the Intensities of the D Lines of Sodium," Vivian Voss; "On the Thermodynamics of Fluorescence," E. H. Kennard; "Kathodo-Fluorescence of Crystals," Thomas B. Brown; "The Necessary Physical Assumptions Underlying a Proof of the Planck Radiation Law," F. Russell v. Bichowsky; "On Certain Absorption Bands in the Spectra of the Uranyl Salts," H. L. Howes; "Resonance Radiation of Sodium Vapor Excited by One of the D Lines," R. W. Wood and Fred L. Mohler.

Popular Astronomy, for February; *Northfield, Minn.; $3.50 per year:* "Earlier Photography of the Firmament," Charles N. Holmes; "The Lunar Saros," William F. Rigge; "The Path of the Moon's Shadow," Frederic R. Honey; "Canopus as Seen from Florida," Jennie L. Kyle; "The Total Solar Eclipse of 1918, June 8," Edwin B. Frost; "Cloud Conditions Along the Path of Totality 1918, June 8," David Todd; "Suggestions Concerning the Place of the Zodiacal Light in the Solar System," Rev. W. E. Glanville; "The Principle of the Conservation of Moment of Momentum," F. R. Moulton.

School Review, for February; *University of Chicago Press; $1.50 per year, 20 cents a copy:* "Significant Results of Missouri and New Mexico Commercial Education Surveys," Paul S. Lomax; "The Part Time Plan in the Centralia (Illinois) Township High School," Eston V. Tubbs; "The Junior High School—Its Place in the Reorganization of Education," Arthur J. Jones.

School World, for January; *Macmillan and Company, London, Eng.; 7s. 6d. per year:* "Science and Invention," Alan A. C. Swinton; "Considered Suggestions for Educational Reform, Pros and Cons, II."

Teachers College Record, for November; *Teachers College, New York City; $1.50 per year, 40 cents a copy:* "Experiment in Education," Frank M. McMurry; "Experimental Teaching and Its Relation to Elementary Education," Grace A. Day; "The Value of Supervised Study," Grace A. Dunn; "Significant Movements in Secondary School Mathematics," Raleigh Schorling; "Camouflage," Alon Bement; "Some Sugar Saving Sweets for Every Day," May B. Van Arsdale and Day Monroe.

BOOKS RECEIVED.

Textbook of Botany, by Charles E. Allen and Edward M. Gilbert, University of Wisconsin. Pages x+459. 13x19 cm. Cloth. 1917. $1.48. D. C. Heath and Company, Boston.

Principles of Economic Zoology, by L. S. Dougherty and M. C. Dougherty, Normal School, Kirkville, Mo. Pages ix+428+11. 14.5x20.5 cm. Cloth. 1917. $2.00 net. W. B. Saunders Company, Philadelphia.

A Short History of Science, by W. T. Sedgwick and H. W. Tyler. Massachusetts Institute of Technology. Pages xv+474. 15x22.5 cm. Cloth. 1917. $2.50. The Macmillan Company, New York City.

Agricultural Bacteriology, by H. W. Conn, Wesleyan University. Pages x+357. 14x20 cm. Cloth. 1917. $2 net. P. Blakiston's Son & Co., Philadelphia, Pa.

Fifty Years of American Education, by Ernest C. Moore. 96 pages. 13.5x19.5 cm. Cloth. 1917. Ginn & Company, Boston.

Plane Trigonometry, with Tables, by Eugene H. Barker, Polytechnic High School, Los Angeles. Pages vii+172. 16x23.5. Cloth. 1917. $1.00 net. P. Blakiston's Son & Co., Philadelphia, Pa.

Commercial Algebra, by George Wentworth, David E. Smith and William S. Schlauch. Pages v+266. 13.5x19 cm. Cloth. 1917. $1.12. Ginn & Company, Boston.

BOOK REVIEWS.

Mathematics for Agriculture and General Science, by A. M. Kenyon, Professor of Mathematics, and W. V. Lovitt, Assistant Professor of Mathematics, Purdue University. Pages vii+357. 13×19 cm. $2.00. 1917. The Macmillan Company, New York.

The parts of college algebra, trigonometry, and analytic geometry which are most useful in practical work, both in and out of college, are presented in this volume. It covers a course of three hours a week for one year. The topics have been wisely chosen and clearly discussed. A very large number of problems, including much data taken from agricultural and other experiments, shows the application of general principles to problems which arise in real life. Chapters in land surveying, statics, small errors, compound interest law, probability, and correlation give further real applications. H. E. C.

College Algebra, by E. B. Skinner, Associate Professor of Mathematics, The University of Wisconsin. Pages vii+263. 13×19 cm. $1.50. 1917. The Macmillan Company, New York.

To meet the changes that have taken place in the teaching of secondary school mathematics, and to emphasize the immediately practical side of algebra, this textbook makes some decidedly interesting changes in the traditional course in college algebra. Elementary material is presented from the viewpoint of maturer students and illustrative problems from geometry, physics, the theory of investment, and other branches of pure and applied science lend interest and show the use made of algebra in these fields. The functions which occur most frequently in practical work receive considerable attention. The generous use of geometrical interpretations will aid students in getting a concrete understanding of algebra. H. E. C.

Junior High School Mathematics, First Course, by W. L. Vosburgh, Head of Department of Mathematics in the Boston Normal School, and F. W. Gentleman, Junior Master, Department of Mathematics, The Mechanic Arts High School, Boston. Pages vii+146. 13×19 cm. 75 cents. 1917. The Macmillan Company, New York.

This book gives work in arithmetic for the seventh school year. It includes a review of the preceding arithmetic, equations of the simplest type, measurement, percentage, interest, and areas of simple plane figures. The problem material is selected from situations of interest to the child, and due effort is made to accustom the pupil to the standards of the business world. H. E. C.

Differential and Integral Calculus, by H. B. Phillips, Ph. D., Assistant Professor of Mathematics in the Massachusetts Institute of Technology. Pages, Part I, v+162; Part II, v+194. 13×19 cm. Combined edition. $2.00. 1917. John Wiley & Sons, Inc., New York.

In order that the student may learn principles and gain power, a few central methods are set forth and applied to a large variety of problems. By this plan less time than usual is given to differential calculus, leaving

more time for integral calculus which in general plays a more important part in engineering problems. Throughout the book practical applications are made in close connection with derivation of rules for differentiating and integrating. Lists of supplementary exercises are given at the end of each part. H. E. C.

Some Agricultural Textbooks.

We have received for review five very excellent books of especial interest to agriculturists because of their merit. The books are of course of value to others interested in their fields. It would seem that the field of agriculture is receiving the help of better writers of textbooks than the older departments of biological science—botany and zoology. This is probably due to the spur of the development of a new field.

School Entomology, Sanderson and Peairs, Wiley Technical Series.
Mycology and Plant Pathology, Harshberger, Blakiston & Sons.
Soils and Fertilizers, Lyon, The Macmillan Company.
Productive Agriculture, Gehrs, The Macmillan Company.
Botany of Crop Plants, Robbins, Blakiston & Sons.

School Entomology. It has been estimated that the annual damage from harmful insects in the United States amounts to 1,000,000,000 dollars. This is talking about money in war terms, but it ought to be war terms, war against harmful insects. Books like *School Entomology* are the best of ammunition with which to fight the evil. Knowledge of the problem is the first essential, then study of methods may follow. This book is intended for use in secondary schools, and it is admirably adapted for the purpose, either as a textbook where possible, or as a reference book where time does not permit a more formal use.

It is divided into two parts—general entomology and economic entomology. The authors seem to have been very wise in their selections of what to use and what to omit and, what is of much importance, have not tried to do too much, to bring in too many forms and facts, and thus bewilder the student.

The second part seems to be especially good and is to be commended

for its clear statements of methods of control and destruction of insect pests. The reasons for the recommended treatment are clearly stated and very helpful. The book is well illustrated. A large number of species of insects are shown in small space by means of photographs. There are 356 pages, 233 figures and plates, size is 13×19 cm., price $1.50 net.

Mycology and Plant Pathology. This book is intended for college use, but will make a very useful reference book for all interested in diseases of plants. Its scope is truly wonderful—we may find anything from the scientific presentation of the morphology, histology, physiology, ecology, and chemistry of fungi to spraying tables showing the same painstaking care in preparation, on the practical side. The book is really cyclopaedic in its scope and variety of topics. We cannot give space here to give it an adequate review, but a list of the divisions or parts into which the book is divided will help give an idea of what it contains. They are: Part I, "Mycology"; Part II, "General Plant Pathology"; Part III, "Special Plant Pathology"; Part IV, "Laboratory Exercises in the Cultural Study of Fungi."

There are extensive lists of specific diseases of plants with references to literature on these diseases. There are also bibliographies for each of the more important topics treated. The descriptions of diseases are concise and clear, and each is accompanied with directions for control or treatment. There are specific directions for making the various spraying compounds with hints as to their use and references for more detailed instructions. Pages 779, figures 268, size 14×19 cm., price $3.00 net.

Soils and Fertilizers. This is a book that can be recommended without reserve within its field—the secondary school. The presentation, arrangement, and balance are all good. The paragraphs are short and to the point. It is broad in its viewpoint and very practical in many ways, fitting the teaching to the farm's actual needs.

There are abundant laboratory exercises with each chapter, and a set of questions whose aim is to develop thinking. There are helpful illustrations and tables. Pages 255, figures in text 34, plates XVI, size 13×19 cm., cost $1.10.

Productive Agriculture. This book is designed to meet the need of elementary school agriculture—for seventh and eighth grades. Probably it would be better fitted for ninth grade work of the high school, where agriculture is given in this grade. The book is very carefully written by one who evidently understands what is needed for these grades of students. Its treatment of the topics is not childish and even silly as is the case very often when authors try to write science textbooks for young people.

The topics are well chosen and we must specially commend the last section on farm management, covering the choosing of the farm, planning a farm, farm bookkeeping, farm labor, and animal husbandry from the management point of view. These are very important divisions of the subject, and it is in these departments that most farmers fail when unsuccessful.

We do not approve the order in which the topics are arranged. The order is crops, animal husbandry, soils, plant propagation, and farm management. The fundamental things are the plant and the soil and their relation to each other. We believe that young people appreciate a logical development of a topic as well as older people, in fact it is more important that the topics be presented in their right relation with each other. We also find that a really fine presentation of the topic of soils is made without even a hint that a plant has such a thing as a root! In fact the plant as a living thing is wholly omitted.

There are abundant tables of statistics where needed and laboratory exercises with each chapter. The illustrations are particularly good. Pages 436, figures 186, graphs 18, numerous tables, size 14×17 cm.

Botany of Crop Plants. This is a college textbook and of course has no use as a secondary school textbook, but as a reference book it will be invaluable to teachers of modern botany and agriculture. Part I, including the first seven chapters, treats of the fundamental structures of plants, and Chapter VIII, the classification of plants. Part II begins the real work of the book, the botany of crop plants by families, beginning with the Gramineae. Thirty-two families of plants are taken up in as many chapters. The author has had in mind nonagricultural as well as agricultural schools on account of the modern tendency to tie the subject up more closely with economic interests.

The treatment of each crop plant is very complete, including the habit of the plant, the flower in detail, the grain (if a cereal) in detail, classification of species and varieties with their characteristics, origin, environmental relations, uses, production, and finally a bibliography. It will be seen that a book of this sort must be an exceedingly useful book for the teacher of botany and agriculture in secondary schools who wishes to illuminate the daily work with something more than the textbook in use may give. Botany teachers especially must realize that their subject must be more closely allied with the practical affairs of life, the more so as it can be done in this case without taking anything from the scientific value of the work in botany—if the teacher understands both botany and agriculture.

There are 683 pages, 263 figures in the text, size 14×19 cm., and the price is $2.00 net. W. W.

Comparative Anatomy of Vertebrates, by J. S. Kingsley, Professor of Zoology in the University of Illinois. Second Edition, revised, with 406 illustrations and 449 pages. 15×22 cm. $2.50 net. P. Blakiston's Son & Company, Philadelphia.

This revised edition has been largely rewritten and carefully revised. We do not need to say anything about the merits of such a well known and standard college textbook. It is a fine specimen of bookmaking, especially in the matter of illustrations, which are largely original. To one wishing work in this line the book should be indispensable.

W. W.

Animal Micrology, Practical Exercises in Zoological Micro-Technique, by Michael F. Guyer, Ph. D., Professor of Zoology in the University of Wisconsin. Revised edition, with 74 illustrations and 289 pages. 15×22 cm. $2.00 net. The University of Chicago Press, Chicago.

This second edition of this well-known book has been revised to bring it up to date so far as possible, by incorporating the most important of the many new methods of technique being constantly developed by students of zoology. Such a book as this is needed, but most of all it needs to be up to date to be of greatest value. There are two new chapters added in this edition, one on "Cytological Methods" and one on "Drawing" by Dr. Elizabeth A. Smith.

The aim has been to give space for only the most important methods, for the number of methods is legion. There are several appendices, one of the most important of which for the student user is a "Table of Tissues and Organs with Methods of Preparation." This should be a very time-saving help for the student. W. W.

Microbiology, a Textbook of Microorganisms, General and Applied. Edited by Charles E. Marshall, Professor of Microbiology, Massachusetts Agricultural College. Second edition. 186 illustrations. Pages 899. 14×18 cm. $3.00 net. P. Blakiston Son & Co., Philadelphia.

This book is a compilation by twenty-five experts on microbiology, each contributing an article on the topic with which he is most familiar. Microbiology takes in such a wide field that some such plan as this is necessary to cover it satisfactorily. It is impossible in the space at command to give any adequate idea of the topics covered by the book. Diseases of man and domestic animals occupy only one-fourth the space. Some of the other topics treat of microbial diseases of plants, of insects, of special industries, of milk and its products, of the air, of water and sewage, and of the soil. Parts I and II take up the morphology and culture of microorganisms and their physiology.

It should be a valuable source book for anyone interested in the subject, and especially for the secondary teacher of physiology.

W. W.

A Textbook of Botany for Colleges, by William F. Ganong, Ph. D., Professor of Botany in Smith College. Part II, pages i-ix and 391-595, with 125 illustrations. 13×18 cm. $1.00. The Macmillan Company, New York.

This second part of Dr. Ganong's textbook completes the work begun with the first part on the "Structures and Functions of Plants." It is designed primarily for those students who take a course in botany as a part of their general education. The treatment is general rather than technical, details being largely omitted. As the size of the book indicates, much had to be omitted, but the emphasis is on the natural history side rather than the morphological details.

Part II includes the "Kinds and Relationships of Plants." Each of the great groups and their classes is taken up for discussion in order, beginning with the thallus plants. The style is clear and simple as always by this author. The illustrations are good, especially the life cycles. W. W.